CORRELATION COEFFICIENTS CALCULATED ON A WORLD WIDE BASIS BETWEEN OBSERVED SECCHI DEPTHS AND OTHER SIMULTANEOUSLY MEASURED STANDARD OCEANOGRAPHIC PARAMETERS

Patrick Joseph Brown

~~LIBRARY~~
~~NAVAL POSTGRADUATE SCHOOL~~
~~MONTEREY, CALIF. 93940~~

[illegible]

DUDLEY KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA 93943

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

CORRELATION COEFFICIENTS CALCULATED
ON A WORLD WIDE BASIS
BETWEEN OBSERVED SECCHI DEPTHS
AND OTHER SIMULTANEOUSLY MEASURED
STANDARD OCEANOGRAPHIC PARAMETERS

by

Patrick Joseph Brown

Thesis Advisor: S. P. Tucker

March 1973

T156422

Approved for public release; distribution unlimited.

Correlation Coefficients Calculated on a World Wide Basis Between Observed Secchi Depths And Other Simultaneously Measured Standard Oceanographic Parameters

by

Patrick Joseph Brown
Lieutenant, United States Navy
B.S., United States Naval Academy, 1967

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OCEANOGRAPHY

from the

NAVAL POSTGRADUATE SCHOOL
March 1973

LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIF. 93940

ABSTRACT

The distributions of Secchi depths (i.e. water transparency) with simultaneously measured standard oceanographic parameters on file at the National Oceanographic Data Center are surveyed on a global basis. An inventory of many of the oceanographic parameters is given for all Marsden squares. Correlation coefficients between Secchi depths and eleven other parameters are also tabulated. Linear regression equations for some twenty-one selected ocean areas relating Secchi depth and the other parameters are presented, and in some cases plotted. No simple and consistent relations between Secchi depth and other parameters are evident; however, several trends are noted. Forel color and oxygen measurements show trends toward an inverse proportionality with Secchi depths while bottom depth data indicate a possible direct proportionality.

TABLE OF CONTENTS

I. INTRODUCTION -- 8

A. GENERAL -- 8

B. PURPOSE -- 10

C. THE SECCHI DISC ------------------------------- 11

II. DATA PROCESSING ------------------------------ 15

A. TREATMENT OF DATA ----------------------------- 15

B. BIOMEDICAL COMPUTER SYSTEM PROGRAMS ------- 19

1. General -- 19

2. BIOMED 02D ------------------------------------ 19

3. BIOMED 02R ------------------------------------ 19

III. DISCUSSION OF RESULTS ------------------------ 23

A. DATA SURVEY ------------------------------------ 23

B. CORRELATION COEFFICIENTS AND LINEAR REGRESSION ANALYSIS ---------------------- 23

1. Color -- 24

2. Sea Surface Temperature ------------------ 25

3. Salinity --------------------------------------- 26

4. Bottom Depth ---------------------------------- 27

5. Density -- 28

6. Oxygen --- 28

7. Total Phosphorous ---------------------------- 29

8. Silicate --------------------------------------- 29

9. Nitrate, Nitrite, and Phosphate ------- 30

10. Cloud Cover ----------------------------------- 30

11. Latitude and Longitude ------------------- 30

C. MONTHLY AVERAGES ------------------------------ 31

IV. CONCLUSIONS -- 32

V. SUGGESTIONS FOR FURTHER RESEARCH ----------------- 33

APPENDIX A: EXAMPLE OF DATA SCREEN PROGRAM ----------- 110

APPENDIX B: EXAMPLE OF BIOMED 02R OUTPUT ------------- 113

BIBLIOGRAPHY -- 116

INITIAL DISTRIBUTION LIST ------------------------------- 118

FORM DD 1473 -- 122

LIST OF TABLES

I. Marsden Square Data Distribution Table --------- 35

II. Area Delineation Table -------------------------- 45

III. Parameter Correlation Coefficient Summary ------ 48

IV. Parameter Mean Summary ------------------------- 55

V. Linear Regression Analysis Results ------------- 58

VI. Graph Data Density Code ------------------------ 65

LIST OF FIGURES

1 Area Delineation Map ---------------------- 34

2 Correlation Coefficient Graphs-------------- 51

3-9 Forel Color vs. Secchi Depth Graphs ------- 66

10-12 Sea Surface Temperature vs. Secchi Depth Graphs ----------------------- 73

13-23 Salinity vs. Secchi Depth Graphs ---------- 76

24-28 Bottom Depth vs. Secchi Depth Graphs ------ 87

29-31 Sigma-t vs. Secchi Depth Graphs ----------- 92

32-33 Oxygen vs. Secchi Depth Graphs ------------ 95

34 Total Phosphorus vs. Secchi Depth Graph --- 97

35 Silicate vs. Secchi Depth Graph ----------- 98

36 Nitrate vs. Secchi Depth Graph ------------ 99

37 Nitrite vs. Secchi Depth Graph ------------ 100

38 Phosphate vs. Secchi Depth Graph ---------- 101

39 Cloud Cover vs Secchi Depth Graph --------- 102

40-42 Latitude vs. Secchi Depth Graphs----------- 103

43-44 Longitude vs. Secchi Depth Graphs---------- 106

45-46 Monthly Secchi Depth Averages-------------- 108

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to Professor Stevens P. Tucker, my thesis advisor, for his endless encouragement and guidance during this study. Dr. Tucker's assistance, enthusiasm and insight aided greatly during the project. I would also like to thank Professor Robert S. Andrews for suggestions during the final stages of this study. This project would not have been possible if not for the data tapes provided through the special efforts of Mr. Henry Odum of the National Oceanographic Data Center. These data tapes were funded by the Office of Naval Research (Arlington, Va.). I am also indebted to Mr. David Norman of the computer facility for the many hours of programming and trouble-shooting in adapting the data tapes for use on the Postgraduate School computer. Lastly, I would like to thank my wife Sue for hours of labor and months of patience.

I. INTRODUCTION

A. GENERAL

The optical properties of sea water govern a great portion of the nature of the oceans of the world. Light penetration below the sea surface is of interest in a large number of areas, since it is due to this characteristic that animal and plant are allowed to exist in the oceans. Strangely enough, studies of the optical nature of sea water seem to have received less emphasis than the extensive investigations by chemists and biologists. In years to come, optical oceanography will play a larger role in our biological, physical and military studies of the oceans.

Arsen'yev and Voytov (1968), in their studies of Bering Sea water, noted the possibility of an inverse relationship between the level of plankton biomass and sea water transparency. Uda (1963) found that transparency (i.e. Secchi depth) and dissolved oxygen measurements could be helpful in investigating productivity levels. Kampa and Bowden (1957) have shown that vertical migrations of deep scattering layers depend directly on light penetration below the sea surface. Voitov and Dement'yeva (1971) analyzed the relationship between transparency and the plankton concentration in Antarctic and Indian waters. They concluded that the depth to which the Secchi disc can be seen underwater is a function of plankton content and suspended terrigenous material, the

distribution of which is linked with hydrodynamics. Ryther (1969) has estimated that over half of the worlds fish supply is produced in no more than 0.1% of the ocean. This fact, coupled with the necessity of light energy for growth of plants in the sea will make future research in optical oceanography of greater significance to the biologist.

An important part in the understanding of the oceans on a global basis lies in the realm of optical oceanography. For example, Jerlov (1968) has proposed a scheme of classification of ocean waters of the world into several oceanic and coastal optical groups by irradiance characteristics. This was an important step in optically grouping similar waters over the world.

Militarily, sea water optics has always been important. It is vital for a submarine commander to consider the water transparency, since his vessel's hull is continually susceptible to visual detection by patrol aircraft and surface ships. Boden, Kampa and Snodgrass (1960) and Kampa (1970) have reported an apparent correlation between extinction coefficients and thermocline depths. These depths at which significant thermal changes take place are of considerable importance to buoyancy control in a submersible. A slight change in the light conditions below the surface can also affect visual mine detection and diver operations as well as determine the success or failure of underwater photography.

Serving as the primary source of energy for organisms in the oceans, light supports photosynthesis and permits life

in the sea. Through the study of light penetration, man may someday achieve greater control of the immense potentials of the oceanic harvests. Murphy (1959) describes this effect of water transparency on the albacore fishing industry.

For purposes of discussion in this paper, "transparency" refers to the average of the depths at which the Šecchi disc disappears upon lowering and reappears upon raising. "Color," or "Forel color," is the color code obtained by the comparison of the color of the Secchi disc when lowered to a depth of one meter with a standard color scale such as the Forel-Ule scale. Beam attenuation coefficient (α) is a measure of the attenuation of a collimated light beam through a fixed path length. Irradiance is a measure of the light flux per unit area striking a horizontal subsurface plane. Vertical extinction coefficient (K_λ), or diffuse attenuation coefficient, is a function of wavelength and is defined as follows:

$$I_z = I_o e^{-K_\lambda Z}$$

where

K_λ = vertical extinction coefficient [meters^{-1}]
I_o = irradiance at the sea surface
I_z = irradiance at depth = Z meters

B. PURPOSE

The purpose of this investigation is to analyze Secchi disc measurements and, on a selected area basis, determine,

if possible, correlations between these and other simultaneously measured standard oceanographic parameters. This was accomplished using the Naval Postgraduate School IBM System/360 Model 67 computer and the Biomedical System library available. Global data was obtained from the National Oceanographic Data Center, Washington D. C.

C. THE SECCHI DISC

Over the years, the Secchi disc has become a widely used tool by which oceanographers and marine biologists have measured water transparency. Commander Cialdi and Professor Secchi (1968) made first mention of its use after observations at sea in 1865. Secchi analyzed how the disc visibility changed as a function of its color, the solar altitude, sea surface reflections, ship's shadow, sky clearness, water color, and the height of eye above the water surface. Encountering near perfect sea conditions, he observed an increase in disc visibility with increased solar altitude and disc whiteness.

Poole and Atkins (1929) measured submarine illumination in the English Channel and developed a widely used empirical formula relating Secchi depth (Z_s) and vertical extinction coefficient (K):

$$K \cong 1.7/Z_s \ [m^{-1}],$$

where Z_s is measured in meters.* This is equivalent to saying that the illumination at the Secchi depth is about 16% that penetrating the water's surface. Gall (1949) independently confirmed this in separate readings ranging from 16% to 25%. Bumpus and Clarke (1947) in their studies on oceanic, coastal and harbor water also provided confirmation of this relationship. Murphy (1959), for example, estimated the ecological effect of water transparency on albacore catches using this equation. Holmes (1970) has mentioned that although the Secchi depth measurement is not precise and is dependent upon many variables, it is still useful as a practical measure. For instance, biologists interested in primary production have come to use three times Secchi depth as an estimate of the depth of the euphotic zone. Holmes (1970) proposed the Poole-Atkins constant of 1.7 should be reduced to 1.44 for turbid water calculations. Russell and Clarke (1944a, 1944b), in a series of cruises, measured transparency in a number of oceanic and coastal areas. Among items they noted to affect transparency were bottom depth, zooplankton and phytoplankton content, water mass movement and harbor runoff. Atkins,

---

* Henceforth K is written without the subscript λ. It is to be understood that the dominant wavelength in the case of K obtained from Secchi data is determined by a number of factors, including the spectral attenuation of sea water, the spectral distribution of incident solar radiation, and the spectral acuity of the observer's eye.

Jenkins and Warren (1954) examined suspended matter in sea water and its seasonal effect on Secchi depth readings. They oberserved an inverse relation between the amount of phytoplankton and the visual range of the disc. Graham (1966) compiled and analyzed Secchi depths, vertical extinction coefficients and Forel color data from several cruises. Multiple regression formulas were obtained expressing the vertical extinction coefficient as a function of color and the reciprocal of Secchi depth. Graham noted the excellent agreement between vertical extinction coefficient and Secchi depth but added caution must be heeded when extrapolating from one area to another. Visser (1967) examined the effect of wave action on disc visibility for different disc sizes and concluded a fair relationship between observed mean Secchi depth in meters and the corresponding percentage yellow in the Forel color according to the formula:

$$\frac{100}{Z_s} = .26Y + 1.9,$$

where Y represents the percent yellow of the water.

Tyler (1968) discussed the theory of how the Secchi depth can be used to calculate the sum of the vertical extinction coefficient (K) and the beam attenuation coefficient (α) utilizing the formula:

$$\frac{3.78\ K}{(\alpha + K)} = \frac{Z_s}{Z_{10\%}} \quad ,$$

where $Z_{10\%}$ represents the depth in meters at which 10% of surface illumination was measured.

Holmes (1970) followed Tyler's recommendations and found no change in disc visibility as a result of varying disc size. He also concluded that using a viewer below the sea surface made no difference in relatively turbid water. Holmes suggested that the pulsating subsurface light field created as a result of wave action, when combined with vertical disc movement, was responsible for compensating for the loss of contrast caused by glare and refraction at the surface. Holmes, too, was interested in the correlation between Secchi depth and the thickness of the euphotic zone. Visser (1969) as well confirmed the biologists' euphotic zone rule-of-thumb and, in addition, independently confirmed the Poole-Atkins relationship.

II. DATA PROCESSING

A. TREATMENT OF DATA

Oceanographic data from some 86,258 stations were received on magnetic tape from the National Oceanographic Data Center. The information included all data recorded on the station A-sheets at sea including all chemistry. Limited computer storage available necessitated screening data to eliminate storing measurements not to be used in this study. The original data, however, have been preserved and remain at the Naval Postgraduate School for future work. Station data selected for analysis were:

- Secchi Depth
- Latitude
- Longitude
- Marsden Square
- Water Depth
- Forel Color
- Cloud Cover
- Month of year
- Sample Chemistry:
    - Temperature
    - Salinity
    - Sigma-t
    - Oxygen
    - Phosphate
    - Phosphorus
    - Nitrite
    - Nitrate
    - Silicate
    - Sample pH

Data obtained but not utilized in this study are:

- Cruise Identity Code
- Station Identity Code
- Country Identity Code
- Date/Hour of Sample
- Number of Observations at this Station
- Wave Height/Direction
- Wind Direction/Speed
- Barometric Pressure
- Weather Information
- Air Temperature
- Sound Velocity

Due to computer storage limitations, only sea surface data were analyzed. Following disc storage of the data, it was necessary to scan by Marsden Square and tabulate all measurements available for analysis. The results of this survey are included as Table I and serve as a reference as to what data are available worldwide. Data were extremely sparse beyond Marsden Square 571; therefore, they were not analyzed. It is seen from Figure 1 and Table I that the great majority of Secchi disc measurements are concentrated along the shipping routes of the world. Worthy of mention is the lack of open ocean data and the abundance of measurements in Japanese coastal waters.

Upon completion of the initial data survey, it was necessary to select a number of areas of interest for analysis. The selection process was based on the following three considerations. First, attention was given to areas of high data density, since a more representative analysis results from

a larger data sample ; second, consideration was given to areas of greater oceanographic interest such as upwelling regions and major current systems, and an attempt was made to insure there was a complete cross section of all water types; and finally, emphasis was given areas of some military interest. Using these criteria, 44 areas were selected, and correlation coefficients and cross tabulation plots were obtained for each using the computer program BIOMED 02D.

To aid in the analysis of data distribution, all data were further broken down by one-degree Marsden sub-squares. This tabulation was used to analyze as much data as possible in as small an area as was reasonable. In this way unnecessary averaging of data from varying water types was avoided. At times, especially in areas near Japan, it was necessary to select segments of high data Marsden squares for analysis, since attempting to analyze data for all squares would have exceeded computer storage limitations. For example, nearly 700,000 bytes were required to analyze area 7 (Shikoku Basin). Likewise, when data were sparse, several Marsden squares were combined to form an analysis area. Table III is a summary of correlations obtained for the 44 areas chosen, and Figure 2 shows parameters from several areas plotted for comparison.

After linear plots and correlation coefficients were obtained for all areas, 21 regions were selected for further analysis using the BIOMED 02R least squares approximation linear regression program. Figures 3 through 44 show some of the more successful results of these analyses and are

discussed in Section III of this report. The selection of the 21 areas for regression analysis was based on visual inspection of the linear plots for some evidence of a consistent relationship between the various parameters and Secchi depth. Daniel and Wood (1971) list several curve types which were used for comparison as were several hand plotted examples of logarithmic and linear relationships. Figure 3 shows a BIOMED 02D graphical output with the corresponding regression curve from BIOMED 02R,plotted. Appendix B is a sample output of the package program BIOMED 02R and Appendix A is an example of the Fortran program utilized to screen data for the BIOMED programs.

Chemistry data at times were too sparse to allow analysis. Table I shows that although temperature and salinity data are usually abundant, such is not the case for measurements of oxygen, phosphate, nitrate, nitrite, and silicate. In light of this, wherever data were plentiful enough, a special effort was made to attempt correlations. The graphs from all areas were compared, and special notice was made of any consistencies. All graphs were analyzed as to special area considerations. For example, Figure 14 shows a plot of salinity and Secchi depth. The wide variation of salinity measurements is presumably due to fresh water runoff into the area. Figure 26 shows water depth plotted against Secchi depth in which transparency is seen to increase with depth. These are examples of special area factors which were considered in the analysis of the graphs and correlation coefficients.

B. BIOMEDICAL COMPUTER SYSTEM PROGRAMS

1. General

The Biomedical (BIOMED) computer programs were developed at the University of California at Los Angeles (Dixon, 1971) and designed for simplicity and convenience. Little previous computer experience is necessary as the programs are in "package" form and require just a few control and system cards to activate.

2. BIOMED 02D (Correlation with Transgeneration)

This program is intended to be basic in data sorting and analysis. Pairs of data, or cases, are selected for inclusion in analysis if they satisfy a specified Boolean statement. This permits exclusion of undesirable or blank data and allows creation of data subsets. Mathematical data manipulations, or transgenerations, are also a feature of the program. Output from this program includes: sums, means, cross product deviations, standard deviations, variance-covariance matrices, correlation matrices, and one page cross-tabulation plots of any two variables. The data density code utilized in BIOMED 02D graphical outputs is translated in Table VI.

3. BIOMED 02R (Stepwise Regression)

This program computes a sequence of multiple linear regression equations in a stepwise manner. At each step, the variable which makes the greatest reduction in the error sum-of-squares is added to the regression equation. The

variable added is the variable which has the highest partial correlation with the dependent variable partialed on the variables that have already been added, and equivalently, it is the variable which, if it were added, would have the highest F value defined below. Variables can also be forced into the equation.

For each step in the stepwise regression procedure, the following are computed:

$$df = n - q$$

$$a_{dd} = \sum_{k=1}^{n} (X_{kd} - \overline{X})(X_{kd} - \overline{X}_d)$$

$$b_{dd} = SS = \sum_{i=1}^{i=n} (y_i - Y_i)^2$$

$$MS = SS/df$$

$$rdf = q$$

$$RSS = a_{dd} - b_{dd}$$

$$RMS = RSS/rdf$$

$$F = RMS/MS$$

where:

n = total number of samples

q = number of variables involved

df = residual degrees of freedom

SS = sum of squares, residual

MS = residual mean square

rdf = regression degrees of freedom

RSS = regression sum of squares

RMS = regression mean square

X_{kd} = the k^{th} value of the independent variable X_d

$\bar{X}_d$ = the mean value of the independent variable X_d

y_i = the i^{th} value of the dependent variable

Y_i = the i^{th} value of the least squares approximation of the dependent variable

As indicated by the above equations, a higher F value shows that a higher degree of confidence may be placed in the presented regression equation. Generally speaking the F value means little until compared with other similarly determined values. The user may also indicate specific numerical values of F which act as limits to allow or prevent the variables from entering the regression equation. Appendix A shows the first two steps of a BIOMED 02R regression analysis output. Boolean case selection available in BIOMED 02D is not a feature in BIOMED 02R. Therefore, it was necessary externally to screen rough data prior to calling upon BIOMED 02R for regression analysis (see Appendix A). At each step in the procedure the multiple correlation coefficient R serves as an indication of how well the regression equation fits the data. With $R = \pm 1.0$, a perfect correlation is indicated. A widely used measure of data fit is the square of the multiple correlation coefficient (R^2). Another option which can be included in the BIOMED 02R output are plots of the residuals (computed Secchi depth minus actual Secchi depth) against the independent variables in the equation.

Analysis of these plots aids in the determination of closer data fits.

A wide selection of transgenerations is available to alter data sets (or subsets) to more desirable forms before inclusion in the analysis.

III. DISCUSSION OF RESULTS

A. DATA SURVEY

Table I shows the data breakdown for Marsden Squares 1 through 571. Frederick (1970) surveyed Secchi disc data and reported that a great deal of the available data were from Japanese waters. This is apparent in Table I which shows large concentrations of data in Marsden Squares 94-97 and 129-132.

Figure 1 and Table I, however, indicate mid-oceanic data to be sparse. Since a study such as the present one must consider all variables affecting transparency measurements, mid-oceanic data would be valuable since the additional dynamic coastal processes tend to complicate matters. If a consistent relationship between an oceanic parameter and Secchi depth is to be found, it would probably be most apparent away from seasonal coastal effects such as fresh water runoff and upwelling. Thus, the lack of mid-oceanic data reported to date is unfortunate.

Secchi measurements are also rare in the polar Marsden squares, and for that reason data are tabulated only through Marsden Square 571. Table IV presents parameter means by area.

B. CORRELATION COEFFICIENTS AND LINEAR REGRESSION ANALYSIS

Tabulated results of BIOMED 02D correlation analyses for the 44 areas appear in Table III and for some areas are plotted

in Figure 2. Table V is a summary of the regression analysis results (BIOMED 02R). Area delineations were made according to Figure 1 and Table II. Figures 3 through 44 are examples of the BIOMED 02D graphical output. Alpha-numeric data density codes are translated in Table VI. A correlation coefficient of ± 1.0 indicates perfect correlations, while a value of 0 signifies no correlation at all (Table III). Correlations between Secchi depths and each parameter will be discussed separately.

1. Color

It is to be noticed, first of all, that Forel color code seems consistently to correlate better than other parameters, as indicated by higher coefficients in Figure 2 and Table III. It is seen that these coefficients are usually negative, signifying lower transparencies for higher color code. A similar pattern was reported by Visser (1967). Figures 3 through 9 show this inverse trend for seven areas, where Forel color is plotted against Secchi depth. An inverse, possibly exponential, trend is unmistakable in Figures 3 through 8; however in Figure 9 for area 35 (Eastern coast of the United States) it is evident this trend is interrupted near colors 7 through 11. Figure 1 shows area 35 to be an area of high fresh water runoff as well as an area of high industrial activity, which accounts for possibly high terrigenous and chemical influences on water color measurements. Several attempts at regression equations were made to relate color code and Secchi depth. These equations

are presented by ocean area in Table V. Figure 3 shows two regression equations for area 7 graphically. Notice that the first approximation (Curve A) achieved a multiple regression coefficient of 0.65, while for the second there is a coefficient of 0.72. Since data density in area 7 (Shikoku Basin) was high, numerous other regressions were attempted as shown in Table V. One of the most successful of these resulted from noticing the apparent exponential nature of the color-Secchi depth graphs. The results were the equations:

Step 1

$$\ell n\ (Z_s) = 3.73 - 0.24\ \text{(Color)} \qquad (R = 0.70)$$

Step 2

$$\ell n\ (Z_s) = 5.05 - 0.17\ \text{(Color)} - 0.3\ \text{(Oxygen[ml/l])} \qquad (R = 0.76)$$

with the multiple regression coefficients listed. Table III shows that higher multiple regression coefficients did result from this study; however, none were as consistently high as those for color code.

2. Sea Surface Temperature

Examination of Table III yields no obvious trends in correlations between sea surface temperature and Secchi depth; however, several interesting cases were encountered. Figures 10 through 12 give several of these. Figure 10 shows temperature and Secchi depth plotted for area 35 (Eastern coast of United States). Notice the large temperature range (25°C)

as compared to Figure 11 for area 12 (Western Pacific Ocean). Figure 1 shows area 35 to be a coastal area, affected by the coastal influences discussed previously for Figure 9. Area 12, on the other hand, is seen to be more oceanic with a resulting smaller temperature range (10°C). A regression line is plotted in Figure 10 on the temperature data from area 35, resulting in a somewhat low multiple regression coefficient of 0.36.

3. Salinity

Nearly all the 44 areas analyzed were coastal areas, subject to localized salinity variations caused by fresh water runoff. This effect can be seen in Figures 13 through 19. In each case, the lower salinity water is associated with decreased transparency. This result is not surprising considering the high levels of terrigenous suspensoids in river waters. Figures 20 and 21 are included for comparison, since they represent somewhat oceanic areas (9 and 12), away from land drainage. The observations are reasonable in that the high salinity variation is not present, and the data are therefore more closely grouped.

Figure 22 shows the salinity and Secchi disc data for area 30 (Peruvian coast). Note that both disc visibility and salinity data variances are small.

Plotted in Figure 23 are Mediterranean Sea data which display the very high salinities characteristic of that area. No significant data correlations resulted for the area.

Superimposed on Figure 18 is the regression line attempted for area 36 (Labrador Sea). This line depicts the equation:

$$Z_s = 2.18 + .01\ (\text{Salinity}\ [°/_{\circ\circ}])^2$$

which results in a multiple regression coefficient equal to 0.85. Due to the extremely local nature of the fresh water runoff, this result would, of course, be of little significance in other coastal areas.

4. Bottom Depth

Bottom depth is closely related to water transparency. As deeper water is encountered away from the coast, three depth-related influences play contributing roles. First, shallow water transparency is determined to a great extent by bottom agitation. The absence of stirred-up bottom sediments in deep oceanic areas cause water transparency to increase. Secondly, the coastal effect of river runoff causes decreased water transparency since these rivers carry large quantities of both suspended and dissolved materials. These suspensoids and solutes may then be carried hundreds of miles by coastal currents and cause great increases in coastal water turbidity. Finally, coastal regions which lie at the eastern extremities of oceans tend to be upwelling areas. In these areas, nutrients from deeper water are carried to the surface and a reduction of Secchi depth results with enhanced phytoplankton growth.

These influences of water depth on Secchi depth can be seen in Figure 2 and Table III, where nearly always a positive correlation coefficient results between bottom depth and water transparency. This indicates an increase in bottom depth is accompanied by an increase in Secchi depth, an anticipated outcome in view of the factors discussed above. The results of this line of reasoning can be seen graphically in Figures 24 through 28, where data from five areas show this direct relationship. Figure 27 shows a regression equation plotted for area 13 (Bay of Bengal), for which a high multiple regression coefficient was attained. Although this trend between bottom depth and Secchi depth was prevalent, it was not always the case as can be seen in Figure 28, where an upwelling area (Equadorian coast) is depicted with bottom depth and water transparency apparently unrelated.

5. Density

No real trend is evident in the sigma-t results presented in Figure 2 and Table III. Figure 29 through 31 are graphs of three coastal areas where the data distribution looks similar to salinity plots given in Figures 13 through 19. Fresh water runoff is postulated as the reason for this in all cases.

6. Oxygen

Figure 2 shows a negative correlation nearly always resulted when measured values of oxygen level and Secchi depths were compared; however, no consistent relationship

was developed. Figures 32 and 33 are graphs of oxygen level and Secchi depth. A regression equation for area 34 (Sargasso Sea) is plotted on Figure 29 yielding a somewhat high multiple correlation coefficient of 0.74. Figure 30 shows the high variability of oxygen data from coastal area 7 (Shikoku Basin). Time variations in oxygen level can be expected due to river runoff and photosynthesis-respiration cycles.

7. Total Phosphorus

Since phosphorus is basic to the growth of phytoplankton in the sea, seasonal and geographic variations of phosphorus level in the coastal areas analyzed can be expected. As phosphorus is returned to the sea upon the death of plants or organisms, it would possibly serve to increase light scattering and thereby lessen penetration depths. This resultant decreasing effect on Secchi depth measurements is evident in Table III and Figure 2, where nearly all correlation coefficients are negative. No consistent correlation level was observed since, in most areas, data were too sparse to permit analysis. Figure 34 shows total phosphorus data plotted.

8. Silicate

Silicate level can be expected to be generally higher in coastal waters due to the effect of land drainage. Although silicate measurements are somewhat sparse, negative correlations did prevail in the areas analyzed as shown in Table III and Figure 2.

Figure 35 shows silicate data for area 28 (Northwestern coast of United States), in the vicinity of the Columbia River discharge. There is an apparent exponential decrease in transparency level as the silicate level increases. Superimposed on Figure 35 is a plot of the equation which was obtained from regression analysis.

9. Nitrate, Nitrite and Phosphate

Figures 36 through 38 are graphs of nitrate, nitrite, and phosphate data, respectively. Without exception, data were too sparse to permit any form of accurate correlation or regression analysis. This lack of data is shown in the breakdown of data, Table I.

10. Cloud Cover

No correlation was noted between the amount of cloud cover and Secchi depth for any of the 44 areas analyzed. Figure 39 shows cloud cover data for area 26 (Gulf of Alaska).

11. Latitude and Longitude

Analysis of Secchi depth data as it varied with latitude and longitude yielded no significant correlations or regression results; however, at times the graphical results were of interest. An example is Figure 40 (Black Sea), where latitude and Secchi depth data are plotted. The influence of river discharge in the northern Black Sea is clearly apparent as water transparency decreases significantly. On the other hand, Figures 41 and 42 show that for the two upwelling areas (both South American coastal areas), transparency is somewhat independent of latitude changes. Figure 43

shows the variation of water transparency with longitude for area 13 on the western extremity of the Indian Ocean. As longitude is increased, greater influence from coastal effects, such as bottom stirring, upwelling, and land drain, are to be anticipated. The data distribution in Figure 43 was therefore, not surprising. In contrast, Figure 44 is a typical data distribution for an area where water transparency is independent of longitude; accordingly, Figure 1 shows area 24 (Aleutian Islands) to be away from these coastal influences.

C. MONTHLY AVERAGES

Monthly Secchi depth averages were plotted in Figure 45 for areas 13 (Bay of Bengal)and 35 (U.S. East Coast). Figure 46 shows Secchi depth averages for upwelling areas 28 (Northwestern coast of United States) and 29 (Peruvian coast).

IV. CONCLUSIONS

Secchi depth readings are influenced by many sea water parameters; among them are sea surface temperature, salinity, density, water depth, color, oxygen, phosphorus level and silicate level. The exact nature of these relationships cannot be determined on the basis of the present study; however, analysis of correlation coefficients yields general trends. Of particular consistency are the high correlation coefficients relating Secchi depth and Forel-Ule color code. Several of the parameters analyzed yielded consistently negative or positive correlation coefficients.

The data survey reveals that water chemistry records in most areas of the world are too sparse for linear regression analysis techniques. Among these are nitrate, nitrite, and phosphate measurements.

Coastal areas under the influence of land drainage present wide ranges of temperature, salinity, density and chemistry readings.

V. SUGGESTIONS FOR FURTHER RESEARCH

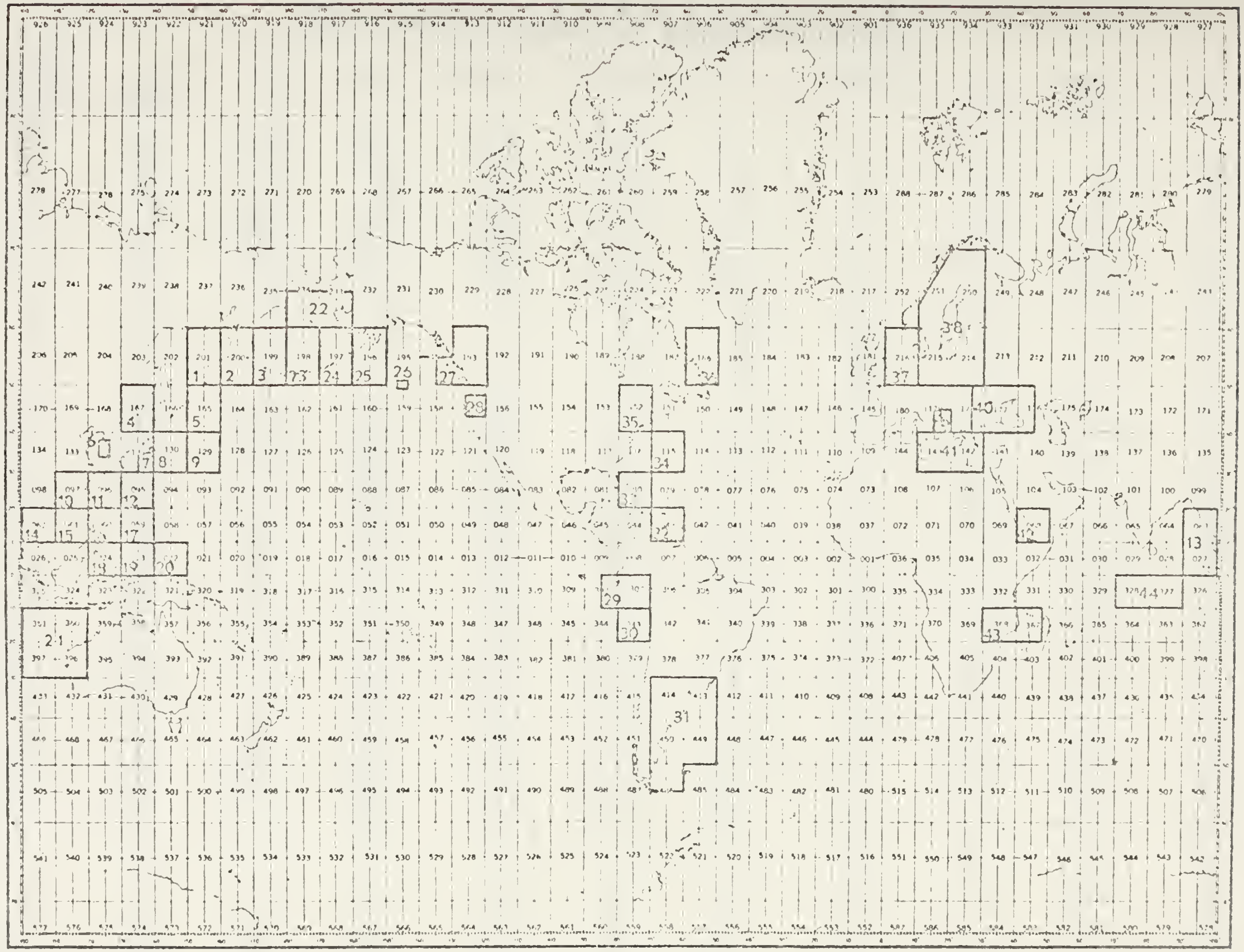
Work should continue to provide better worldwide coverage of Secchi disc measurements and of the other parameters normally sampled.

The scope of this project was limited to sea surface measurement analysis because of computer storage requirements. Further analysis should continue to analyze subsurface parameters and their possible correlation to Secchi disc measurements.

The Secchi disc and procedures for its use should all be standardized to eliminate possible variations in future data due to differing disc dimensions and measurement practices.

As mid-ocean data become available, other studies such as this should be made, since correlations determined free from coastal influences may yield results which can be simply and accurately extrapolated to other open ocean areas.

There exists in use a package program similar to, but superior to, the BIOMED programs. Known as the "Statistical Package for the Social Sciences" or "SPSS" (Nie, Bent, and Hull, 1970), this fully integrated system allows for subfile creation, missing values and conditional transformations. An analysis using SPSS would be superior and much simpler to any BIOMED-based study.



AREA/MARSDEN SQUARE CHART

Figure 1. Area Delineation Map

DATA DISTRIBUTION BY MARSDEN SQUARE

MAR. SQ.	NUMBER STATIONS	SECCHI DEPTHS	TEMP	SAL	SIGMA-t	OXYGEN	PO_4	PHOS	NO_2	NO_3	SIL	pH
1	552	552	1101	1055	1034	545	132	0	6	0	39	154
2	201	200	350	329	327	283	124	1	15	0	52	100
3	10	10	24	23	23	24	22	4	0	0	6	11
4	10	10	12	10	10	6	3	3	0	0	0	2
5	36	17	60	59	59	46	40	3	37	0	0	13
6	33	7	85	85	85	82	57	1	17	0	75	34
7	19	17	58	54	54	58	51	41	40	32	52	52
8	231	231	1297	1186	1183	212	249	0	133	134	148	74
9	93	90	267	252	250	216	100	0	77	83	90	31
10	13	13	36	35	34	37	21	0	12	10	15	0
11	6	6	10	9	9	9	5	0	5	5	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	1	1	3	3	3	3	3	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	5	5	9	9	9	9	0	0	0	0	0	7
16	5	5	11	11	11	11	8	0	8	6	2	9
17	1	1	1	1	1	1	0	0	0	0	0	0
18	6	6	13	13	13	13	7	0	2	0	6	10
19	65	65	128	114	114	19	7	0	0	0	7	12
20	131	131	263	227	227	16	5	0	5	0	5	12
21	250	250	451	352	352	51	21	4	7	11	14	11
22	184	183	360	318	318	77	23	6	9	8	19	33
23	474	471	729	629	629	105	45	0	16	6	58	40
24	212	208	365	340	340	79	44	0	12	6	50	62
25	72	72	137	121	121	0	0	0	0	0	0	0
26	204	203	706	700	700	362	0	0	0	0	0	0
27	111	103	349	338	338	249	62	40	0	6	59	57
28	14	14	38	38	38	27	7	11	15	5	11	18
29	30	30	86	85	85	81	47	14	13	10	45	55
30	12	12	32	32	32	32	5	0	5	0	5	19
31	11	11	29	29	29	29	6	0	2	0	6	21
32	1	1	3	3	3	3	0	0	0	0	0	3
33	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0
36	913	913	2244	2208	2187	1576	9	0	2	0	7	9
37	0	0	0	0	0	0	0	0	0	0	0	0
38	210	207	541	539	536	410	9	0	0	0	0	12
39	11	10	20	20	20	20	11	5	0	0	0	10
40	9	9	19	19	19	16	3	3	0	0	0	13
41	13	13	27	27	27	21	4	4	0	0	1	16
42	11	11	23	23	23	20	4	4	0	0	0	12
43	353	332	1071	1059	1054	854	469	234	344	329	565	458
44	26	24	43	42	39	29	20	4	0	0	0	0
45	19	19	39	38	38	33	12	1	0	3	5	0
46	43	22	120	122	119	123	21	0	5	14	21	0
47	11	11	29	26	26	28	19	0	0	14	16	0
48	0	0	0	0	0	0	0	0	0	0	0	0
49	1	1	3	3	3	3	2	0	0	0	0	0
50	2	2	4	4	4	2	1	0	2	0	2	2
51	3	3	6	6	6	6	2	0	2	0	2	4
52	2	2	5	5	5	5	4	0	0	0	0	5
53	0	0	0	0	0	0	0	0	0	0	0	0
54	4	4	9	9	9	9	5	0	2	0	5	9
55	33	33	65	63	63	23	14	0	0	0	12	14
56	85	85	170	158	158	13	2	0	0	0	2	2
57	162	162	300	254	254	38	18	0	3	9	7	8
58	261	260	506	443	443	62	22	18	7	11	9	24
59	201	197	369	386	386	102	52	0	27	10	70	55
60	248	234	517	513	512	267	159	2	32	23	178	217

TABLE I. MARSDEN SQUARE DATA DISTRIBUTION TABLE

DATA DISTRIBUTION BY MARSDEN SQUARE

MAR. SQ.	NUMBER STATIONS	SECCHI DEPTHS	TEMP	SAL	SIGMA-t	OXYGEN	PO_4	PHOS	NO_2	NO_3	SIL	pH
61	329	307	516	416	416	11	6	0	0	0	8	6
62	850	818	2789	2700	2682	549	53	0	7	0	27	0
63	27	24	83	71	71	18	9	0	0	0	0	0
64	44	44	83	99	76	48	18	0	2	0	0	2
65	4	4	9	9	9	9	5	0	1	0	5	4
66	13	13	31	31	31	31	6	0	6	2	6	13
67	47	47	107	75	75	105	40	0	12	2	31	58
68	63	63	151	67	67	141	69	0	3	1	49	50
69	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0	0	0	0
74	13	13	21	21	21	14	14	0	0	0	5	9
75	9	8	18	18	18	9	3	0	0	0	3	2
76	17	15	28	28	28	17	7	4	0	1	4	4
77	16	14	28	28	28	14	6	3	0	1	2	4
78	21	16	39	39	39	13	5	1	0	0	3	8
79	28	21	69	69	69	26	6	3	0	0	2	21
80	89	84	206	203	203	176	3	0	0	0	5	6
81	53	53	114	112	112	97	0	0	0	0	0	0
82	22	22	26	26	26	26	0	0	0	0	0	0
83	4	4	12	12	12	12	12	0	2	4	5	0
84	8	8	22	22	22	21	10	0	8	4	3	0
85	0	0	0	0	0	0	0	0	0	0	0	0
86	2	2	5	1	1	5	4	0	0	0	4	0
87	2	2	2	2	2	2	0	0	0	0	0	0
88	16	16	31	31	31	27	12	0	2	4	7	9
89	6	6	14	11	11	16	14	0	2	1	12	11
90	11	11	22	22	22	19	15	0	0	0	15	19
91	94	81	110	57	57	20	14	0	1	1	6	8
92	68	67	125	108	108	44	33	0	1	2	18	24
93	187	186	344	294	294	42	24	0	12	11	30	10
94	721	711	1304	1179	1179	171	95	55	24	31	55	132
95	2153	2099	4327	4127	4119	2579	427	0	32	40	207	188
96	2038	1965	4061	3701	3700	1401	743	19	175	156	422	323
97	195	193	495	412	410	50	33	0	20	14	36	36
98	41	40	108	82	81	15	15	0	3	0	9	0
99	0	0	0	0	0	0	0	0	0	0	0	0
100	1	1	1	2	1	2	2	0	2	0	2	2
101	1	1	3	3	3	3	3	0	0	0	3	3
102	7	7	19	19	19	19	13	0	2	0	13	6
103	77	75	218	217	216	208	174	0	2	0	174	0
104	75	71	186	183	179	38	32	0	0	0	32	0
105	13	11	20	20	20	5	0	0	0	0	0	5
106	0	0	0	0	0	0	0	0	0	0	0	0
107	0	0	0	0	0	0	0	0	0	0	0	0
108	0	0	0	0	0	0	0	0	0	0	0	0
109	16	16	32	32	32	6	6	0	0	5	4	0
110	23	22	35	34	34	13	5	2	0	4	4	0
111	10	10	17	17	17	17	9	0	0	1	8	6
112	9	9	17	17	17	8	4	0	0	2	5	0
113	40	40	63	62	62	30	11	0	8	1	15	12
114	17	15	44	44	44	37	3	0	3	1	7	10
115	109	102	234	236	233	152	73	66	47	56	37	18
116	195	191	536	521	513	456	40	15	15	9	15	28
117	23	23	58	58	58	49	0	0	0	0	0	0
118	0	0	0	0	0	0	0	0	0	0	0	0
119	0	0	0	0	0	0	0	0	0	0	0	0
120	9	9	23	26	23	26	2	0	0	0	0	0

TABLE I. (cont'd) MARSDEN SQUARE DATA DISTRIBUTION TABLE

DATA DISTRIBUTION BY MARSDEN SQUARE

MAR. SQ.	NUMBER STATIONS	SECCHI DEPTHS	TEMP	SAL	SIGMA-t	OXYGEN	PO_4	PHOS	NO_2	NO_3	SIL	pH
121	31	31	96	95	95	91	64	0	35	37	13	15
122	14	14	32	27	26	25	17	0	0	0	8	6
123	20	20	48	33	33	48	40	0	6	2	23	9
124	13	13	40	28	28	29	21	0	0	2	15	6
125	12	12	36	29	29	27	17	0	7	5	12	11
126	25	24	63	62	60	28	20	0	5	2	23	15
127	118	110	166	113	113	42	39	0	1	1	20	20
128	186	182	303	238	238	90	68	0	20	13	56	30
129	1433	1422	2979	2771	2771	1994	121	1	27	19	100	122
130	6888	6738	13782	12411	12393	4335	638	20	88	91	560	908
131	17786	17344	45620	42559	42520	20923	7991	58	486	255	13004	3196
132	10008	9861	22723	21180	21161	7595	3658	0	857	3	3914	2327
133	33	31	66	40	39	0	0	0	0	0	0	0
134	0	0	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	0	0	0
136	0	0	0	0	0	0	0	0	0	0	0	0
137	0	0	0	0	0	0	0	0	0	0	0	0
138	0	0	0	0	0	0	0	0	0	0	0	0
139	1	1	2	2	2	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0
141	25	24	50	50	50	49	25	0	0	4	4	0
142	78	77	177	176	176	141	103	0	1	37	66	0
143	59	57	142	141	141	89	56	0	0	6	11	0
144	7	7	7	7	7	7	4	0	0	5	5	0
145	10	9	30	30	30	17	16	1	0	0	0	15
146	20	19	40	38	37	31	16	2	8	0	15	15
147	23	23	47	47	47	38	18	2	16	0	16	22
148	24	23	52	53	51	43	21	2	14	0	20	29
149	87	63	133	134	132	70	30	2	15	0	26	33
150	16	11	35	34	33	20	3	2	4	0	1	6
151	130	130	371	364	360	115	5	3	6	0	6	6
152	1500	1250	4243	4437	4161	1938	107	8	7	5	8	0
153	0	0	0	0	0	0	0	0	0	0	0	0
154	0	0	0	0	0	0	0	0	0	0	0	0
155	0	0	0	0	0	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0	0	0	0	0
157	2141	2130	10133	10323	10084	9674	3533	0	21	1867	2320	107
158	180	179	494	494	492	326	174	0	18	89	129	32
159	199	199	539	524	519	425	108	0	61	15	139	53
160	18	18	56	52	52	51	30	0	23	4	26	34
161	14	14	46	46	46	32	15	0	11	0	4	24
162	77	77	194	181	180	151	80	0	36	9	69	81
163	66	66	157	156	156	41	34	0	19	3	25	37
164	149	145	354	345	345	87	64	0	11	3	51	29
165	859	840	1896	1809	1807	409	141	0	9	2	103	228
166	7071	6953	15699	14152	14139	3650	679	26	44	29	421	568
167	1691	1666	3686	3338	3328	681	429	3	33	0	437	341
168	154	154	319	277	276	69	65	0	0	0	67	102
169	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0	0	0	0	0	0
172	0	0	0	0	0	0	0	0	0	0	0	0
173	0	0	0	0	0	0	0	0	0	0	0	0
174	0	0	0	0	0	0	0	0	0	0	0	0
175	1	1	2	2	2	2	0	0	0	0	0	0
176	11	11	29	25	25	19	0	0	0	0	0	0
177	378	378	1447	1127	1125	212	0	0	0	0	0	67
178	27	27	62	62	61	48	0	0	0	1	3	22
179	1043	1041	2905	2956	2851	1690	883	826	17	81	83	325
180	1	1	1	1	1	1	1	0	0	1	1	0

TABLE I. (cont'd) MARSDEN SQUARE DATA DISTRIBUTION TABLE

DATA DISTRIBUTION BY MARSDEN SQUARE

MAR. SQ.	NUMBER STATIONS	SECCHI DEPTHS	TEMP	SAL	SIGMA-t	OXYGEN	PO_4	PHOS	NO_2	NO_3	SIL	pH
181	8	8	24	24	24	18	4	0	4	0	2	15
182	19	19	56	56	56	44	14	0	12	0	12	23
183	14	14	39	39	39	27	12	0	10	0	12	12
184	49	49	76	67	67	17	12	0	12	0	12	12
185	6	4	17	17	17	7	8	0	2	6	8	2
186	307	306	1104	1033	1026	482	269	0	6	3	6	3
187	128	126	491	392	387	252	135	0	0	0	0	0
188	0	0	0	0	0	0	0	0	0	0	0	0
189	0	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0	0	0
192	0	0	0	0	0	0	0	0	0	0	0	0
193	936	870	5281	5265	5251	3800	199	0	13	0	15	11
194	736	733	3074	3075	3054	2893	918	0	21	96	1222	26
195	336	336	922	909	907	762	175	0	163	21	213	55
196	128	127	329	317	315	189	133	0	28	80	86	36
197	224	220	700	698	686	145	83	0	17	5	54	51
198	198	196	584	551	549	195	155	0	22	0	131	53
199	170	168	468	438	435	135	104	0	6	0	75	44
200	183	177	503	494	491	59	60	0	4	8	31	20
201	503	496	1146	1108	1108	65	40	0	0	0	33	32
202	97	95	242	232	232	10	3	0	0	0	0	4
203	0	0	0	0	0	0	0	0	0	0	0	0
204	0	0	0	0	0	0	0	0	0	0	0	0
205	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0
207	0	0	0	0	0	0	0	0	0	0	0	0
208	0	0	0	0	0	0	0	0	0	0	0	0
209	0	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0
211	0	0	0	0	0	0	0	0	0	0	0	0
212	0	0	0	0	0	0	0	0	0	0	0	0
213	0	0	0	0	0	0	0	0	0	0	0	0
214	184	184	732	706	706	146	14	0	0	2	0	173
215	324	322	1327	1267	1266	142	34	0	19	0	27	93
216	281	281	1111	1107	1103	87	4	0	2	0	4	13
217	63	61	156	142	142	136	106	0	67	0	91	58
218	43	42	102	97	97	92	69	0	28	0	54	34
219	14	8	27	27	27	9	0	0	0	0	0	3
220	12	12	43	28	28	0	0	0	0	0	0	0
221	5	2	12	13	13	11	3	0	0	3	3	0
222	19	17	50	50	48	32	3	0	2	2	2	0
223	26	25	79	80	79	17	0	0	0	0	0	0
224	99	99	338	344	342	0	0	0	0	0	0	0
225	77	77	240	246	244	0	0	0	0	0	0	0
226	12	12	45	46	46	0	0	0	0	0	0	0
227	6	6	24	24	24	0	0	0	0	0	0	0
228	23	23	83	47	47	0	12	0	0	12	0	12
229	8	8	42	0	0	0	0	0	0	0	0	0
230	5	3	17	17	17	3	0	0	0	0	0	0
231	2	2	9	9	9	4	0	0	0	0	0	0
232	8	8	20	24	20	24	0	0	0	0	0	0
233	257	257	1079	1077	1076	752	425	0	0	0	191	56
234	119	118	449	408	406	94	41	0	0	0	30	115
235	33	32	109	100	100	14	10	0	2	0	4	10
236	4	4	13	13	13	3	0	0	0	0	0	0
237	0	0	0	0	0	0	0	0	0	0	0	0
238	0	0	0	0	0	0	0	0	0	0	0	0
239	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0

TABLE I. (cont'd) MARSDEN SQUARE DATA DISTRIBUTION TABLE

DATA DISTRIBUTION BY MARSDEN SQUARE

MAR. SQ.	NUMBER STATIONS	SECCHI DEPTHS	TEMP	SAL	SIGMA-T	OXYGEN	PO_4	PHOS	NO_2	NO_3	SIL	pH
241	0	0	0	0	0	0	0	0	0	0	0	0
242	0	0	0	0	0	0	0	0	0	0	0	0
243	0	0	0	0	0	0	0	0	0	0	0	0
244	0	0	0	0	0	0	0	0	0	0	0	0
245	0	0	0	0	0	0	0	0	0	0	0	0
246	5	5	19	19	19	0	0	0	0	0	0	0
247	0	0	0	0	0	0	0	0	0	0	0	0
248	2	2	6	6	6	0	0	0	0	0	0	0
249	21	21	69	67	67	3	0	0	0	0	0	8
250	290	290	1158	1154	1154	192	15	0	0	11	1	283
251	92	92	311	300	300	84	22	0	12	0	15	74
252	49	49	126	111	111	109	90	0	62	0	84	59
253	31	31	80	79	79	71	64	0	9	0	21	0
254	6	6	18	18	18	16	17	0	1	0	2	1
255	5	5	11	11	11	0	0	0	0	0	0	0
256	0	0	0	0	0	0	0	0	0	0	0	0
257	0	0	0	0	0	0	0	0	0	0	0	0
258	24	24	48	45	41	35	0	0	0	0	0	0
259	48	47	127	114	107	53	0	0	0	0	0	0
260	30	30	77	80	77	64	1	0	0	0	0	0
261	28	28	76	76	76	42	11	0	0	0	0	0
262	33	33	107	105	105	50	22	0	0	0	0	0
263	7	7	21	17	17	14	4	0	0	0	0	0
264	18	18	70	72	70	55	24	0	0	0	0	0
265	10	10	41	41	40	8	7	0	0	0	0	0
266	7	7	38	38	38	3	0	0	0	0	0	0
267	10	10	41	42	42	0	0	0	0	0	0	0
268	19	19	67	68	67	0	0	0	0	0	0	0
269	18	18	75	76	75	39	24	0	0	0	21	0
270	11	11	61	61	61	22	0	0	0	0	0	17
271	23	23	191	192	191	150	0	0	0	0	0	0
272	15	15	126	126	126	111	0	0	0	0	0	0
273	11	11	56	55	55	43	0	0	0	0	0	0
274	2	2	6	6	6	5	0	0	0	0	0	0
275	0	0	0	0	0	0	0	0	0	0	0	0
276	0	0	0	0	0	0	0	0	0	0	0	0
277	0	0	0	0	0	0	0	0	0	0	0	0
278	0	0	0	0	0	0	0	0	0	0	0	0
279	1	1	3	3	3	3	0	0	0	0	0	0
280	39	39	90	89	89	88	0	0	0	0	0	0
281	37	36	101	99	99	96	0	0	0	0	0	0
282	25	25	69	67	67	63	0	0	0	0	0	0
283	72	72	201	193	191	54	0	0	0	0	0	0
284	17	17	50	50	50	43	0	0	0	0	0	0
285	79	79	200	201	201	142	28	0	6	0	28	145
286	33	33	101	101	101	56	0	0	0	0	0	35
287	34	34	88	89	88	46	27	0	16	0	18	12
288	23	23	57	57	57	42	41	0	17	0	18	0
289	0	0	0	0	0	0	0	0	0	0	0	0
290	0	0	0	0	0	0	0	0	0	0	0	0
291	0	0	0	0	0	0	0	0	0	0	0	0
292	0	0	0	0	0	0	0	0	0	0	0	0
293	0	0	0	0	0	0	0	0	0	0	0	0
294	0	0	0	0	0	0	0	0	0	0	0	0
295	0	0	0	0	0	0	0	0	0	0	0	0
296	0	0	0	0	0	0	0	0	0	0	0	0
297	0	0	0	0	0	0	0	0	0	0	0	0
298	0	0	0	0	0	0	0	0	0	0	0	0
299	0	0	0	0	0	0	0	0	0	0	0	0
300	81	81	205	216	202	168	161	6	44	0	58	161

TABLE I. (cont'd) MARSDEN SQUARE DATA DISTRIBUTION TABLE

DATA DISTRIBUTION BY MARSDEN SQUARE

MAR. SQ.	NUMBER STATIONS	SECCHI DEPTHS	TEMP	SAL	SIGMA-t	OXYGEN	PO_4	PHOS	NO_2	NO_3	SIL	pH
301	32	32	85	86	85	74	70	4	11	0	34	59
302	17	16	40	40	40	40	40	5	0	0	0	29
303	15	15	19	16	15	16	3	3	0	0	0	5
304	4	3	8	8	8	5	5	2	3	0	0	0
305	0	0	0	0	0	0	0	0	0	0	0	0
306	0	0	0	0	0	0	0	0	0	0	0	0
307	178	178	524	509	505	505	417	0	2	5	38	0
308	594	593	1715	1627	1624	1513	1056	0	107	52	214	5
309	65	60	174	164	163	175	132	0	81	12	49	0
310	7	7	10	8	8	9	5	0	4	5	0	0
311	1	1	3	3	3	3	3	0	0	0	0	0
312	0	0	0	0	0	0	0	0	0	0	0	0
313	2	2	2	4	2	4	2	0	3	0	2	1
314	1	1	1	1	1	1	0	0	0	0	0	0
315	5	5	12	12	12	12	9	0	7	6	3	12
316	3	3	3	3	3	3	0	0	0	0	0	0
317	8	8	15	15	15	13	6	0	7	0	7	11
318	6	6	12	12	12	8	3	0	0	0	3	6
319	9	9	18	18	18	6	1	0	1	0	1	2
320	36	36	71	59	59	30	19	0	5	6	14	12
321	18	18	43	43	43	32	12	0	0	0	10	11
322	29	28	53	42	42	26	24	0	3	21	4	1
323	95	95	206	193	193	65	63	0	3	57	6	6
324	84	83	164	136	135	11	7	0	4	0	7	7
325	37	37	81	74	74	21	15	0	9	6	15	15
326	54	45	159	159	159	96	64	51	7	21	68	72
327	31	31	71	71	71	35	22	12	16	7	27	20
328	21	21	60	60	60	60	44	24	12	14	45	45
329	7	7	17	17	17	17	10	3	8	2	7	10
330	8	8	18	18	18	18	8	0	4	0	8	14
331	15	15	38	40	38	37	16	0	4	0	16	22
332	0	0	0	0	0	0	0	0	0	0	0	0
333	0	0	0	0	0	0	0	0	0	0	0	0
334	394	393	1042	931	925	493	21	1	0	0	5	64
335	311	308	814	805	802	420	52	4	0	0	4	21
336	8	8	20	20	20	8	8	2	0	0	0	6
337	4	4	8	8	8	5	5	2	0	0	0	3
338	2	2	2	2	2	2	1	1	0	0	0	0
339	10	10	14	10	10	10	2	2	0	0	0	4
340	0	0	0	0	0	0	0	0	0	0	0	0
341	0	0	0	0	0	0	0	0	0	0	0	0
342	0	0	0	0	0	0	0	0	0	0	0	0
343	710	709	2125	2086	2071	2041	1704	0	151	215	436	0
344	40	40	109	104	104	106	95	0	16	29	41	0
345	7	7	9	8	8	9	9	0	9	9	7	0
346	0	0	0	0	0	0	0	0	0	0	0	0
347	0	0	0	0	0	0	0	0	0	0	0	0
348	0	0	0	0	0	0	0	0	0	0	0	0
349	0	0	0	0	0	0	0	0	0	0	0	0
350	3	2	5	5	5	5	2	0	1	0	1	4
351	8	8	15	15	15	14	10	0	4	6	5	12
352	5	5	5	5	5	4	2	0	2	2	1	0
353	4	4	6	6	6	6	2	0	0	0	2	4
354	11	11	13	13	13	2	2	0	0	0	2	4
355	0	0	0	0	0	0	0	0	0	0	0	0
356	15	15	15	15	15	0	0	0	0	0	0	0
357	0	0	0	0	0	0	0	0	0	0	0	0
358	0	0	0	0	0	0	0	0	0	0	0	0
359	30	29	66	65	65	32	25	0	10	8	25	31
360	101	97	246	244	244	67	37	0	22	14	37	44

TABLE I. (cont'd) MARSDEN SQUARE DATA DISTRIBUTION TABLE

DATA DISTRIBUTION BY MARSDEN SQUARE

MAR. SQ.	NUMBER STATIONS	SECCHI DEPTHS	TEMP	SAL	SIGMA-t	OXYGEN	PO_4	PHOS	NO_2	NO_3	SIL	p^H
361	47	47	115	114	114	57	41	3	20	9	41	41
362	15	13	41	41	41	41	34	30	10	20	38	40
363	8	7	20	20	20	20	13	0	6	0	15	6
364	16	16	46	46	46	43	32	20	17	9	38	38
365	6	6	12	12	12	12	8	0	4	0	8	8
366	7	7	15	15	15	15	8	0	8	0	8	8
367	23	23	67	67	67	66	64	0	2	12	64	2
368	7	7	20	20	20	20	20	0	0	6	20	0
369	0	0	0	0	0	0	0	0	0	0	0	0
370	182	182	523	455	451	71	13	1	0	0	2	18
371	18	18	49	49	49	1	22	1	0	0	0	0
372	0	0	0	0	0	0	0	0	0	0	0	0
373	1	1	1	1	1	1	1	1	0	0	0	0
374	2	2	2	2	2	2	2	0	1	0	1	1
375	7	7	7	7	7	7	4	2	1	0	1	2
376	15	15	28	28	28	28	25	0	15	22	24	1
377	0	0	0	0	0	0	0	0	0	0	0	0
378	0	0	0	0	0	0	0	0	0	0	0	0
379	9	9	25	25	25	25	24	0	12	0	24	0
380	3	3	6	6	6	6	6	0	6	1	4	0
381	6	6	7	7	7	7	7	0	5	5	2	2
382	0	0	0	0	0	0	0	0	0	0	0	0
383	0	0	0	0	0	0	0	0	0	0	0	0
384	0	0	0	0	0	0	0	0	0	0	0	0
385	4	4	5	5	5	5	5	0	4	4	4	0
386	2	2	3	3	3	3	1	0	1	0	1	2
387	0	0	0	0	0	0	0	0	0	0	0	0
388	1	1	2	2	2	2	0	0	0	0	0	0
389	5	5	11	11	11	11	6	0	0	0	6	11
390	16	16	21	21	21	9	5	0	0	0	5	8
391	0	0	0	0	0	0	0	0	0	0	0	0
392	0	0	0	0	0	0	0	0	0	0	0	0
393	0	0	0	0	0	0	0	0	0	0	0	0
394	0	0	0	0	0	0	0	0	0	0	0	0
395	0	0	0	0	0	0	0	0	0	0	0	0
396	21	20	56	56	56	38	27	0	1	0	27	37
397	10	10	29	29	29	26	23	3	7	3	20	19
398	5	4	12	12	12	12	10	6	4	3	10	10
399	3	3	7	7	7	7	4	0	4	0	4	4
400	9	9	27	27	27	27	17	9	0	4	18	12
401	3	3	6	6	6	6	6	0	0	0	6	6
402	0	0	0	0	0	0	0	0	0	0	0	0
403	20	20	54	51	51	51	48	0	0	8	51	0
404	30	30	88	87	87	87	80	0	0	21	87	0
405	0	0	0	0	0	0	0	0	0	0	0	0
406	4	4	5	3	3	2	0	0	0	0	0	0
407	2	2	2	2	2	2	2	2	0	0	0	0
408	0	0	0	0	0	0	0	0	0	0	0	0
409	0	0	0	0	0	0	0	0	0	0	0	0
410	1	1	2	2	2	2	2	0	2	0	2	2
411	1	1	2	2	2	2	2	0	2	0	2	2
412	19	17	29	29	29	24	18	0	11	8	13	16
413	181	180	492	488	486	466	401	2	194	390	316	149
414	4	4	12	12	12	8	11	0	3	12	12	0
415	56	56	140	127	125	132	7	0	4	7	5	0
416	6	6	8	8	8	8	5	0	5	5	3	0
417	8	8	8	8	8	8	8	0	7	8	6	0
418	6	6	7	7	7	7	5	0	5	5	3	0
419	4	4	4	4	4	4	4	0	4	4	3	0
420	4	4	3	3	3	3	3	0	3	3	3	0

TABLE I. (cont'd) MARSDEN SQUARE DATA DISTRIBUTION TABLE

DATA DISTRIBUTION BY MARSDEN SQUARE

MAR. SQ.	NUMBER STATIONS	SECCHI DEPTHS	TEMP	SAL	SIGMA-t	OXYGEN	PO_4	PHOS	NO_2	NO_3	SIL	pH
421	0	0	0	0	0	0	0	0	0	0	0	0
422	0	0	0	0	0	0	0	0	0	0	0	0
423	0	0	0	0	0	0	0	0	0	0	0	0
424	1	1	1	1	1	1	0	0	0	0	0	0
425	5	5	12	12	12	12	6	0	0	0	6	10
426	3	3	6	6	6	6	3	0	0	0	3	6
427	3	3	7	7	7	7	7	0	0	0	7	7
428	2	2	4	4	4	4	4	0	0	0	4	4
429	0	0	0	0	0	0	0	0	0	0	0	0
430	2	2	4	4	4	4	4	0	2	0	4	4
431	0	0	0	0	0	0	0	0	0	0	0	0
432	7	5	18	20	18	17	15	3	1	3	11	16
433	5	5	12	12	12	12	9	0	3	0	9	9
434	1	1	3	3	3	3	0	0	0	0	0	0
435	1	1	3	3	3	3	0	0	0	0	0	0
436	1	1	3	3	3	3	0	0	0	0	0	0
437	1	1	2	2	2	2	2	0	0	0	2	2
438	0	0	0	0	0	0	0	0	0	0	0	0
439	1	1	3	3	3	3	3	0	0	0	3	0
440	4	4	12	12	12	12	12	0	0	0	12	0
441	180	174	456	448	448	286	147	0	0	0	0	0
442	558	525	1369	1355	1355	856	435	0	1	0	1	1
443	0	0	0	0	0	0	0	0	0	0	0	0
444	4	4	6	6	6	6	6	0	6	0	6	6
445	3	3	5	5	5	5	5	0	5	0	2	5
446	5	5	6	6	6	6	3	0	3	0	3	3
447	6	6	8	8	8	8	6	0	6	0	6	6
448	21	21	33	33	33	33	33	0	21	14	20	18
449	101	100	239	235	235	226	209	0	118	181	143	102
450	144	141	417	417	416	408	411	0	117	399	281	167
451	3	3	5	5	5	5	0	0	0	0	0	0
452	1	1	1	1	1	1	1	0	1	1	1	0
453	0	0	0	0	0	0	0	0	0	0	0	0
454	1	1	1	1	1	1	1	0	1	1	1	0
455	0	0	0	0	0	0	0	0	0	0	0	0
456	0	0	0	0	0	0	0	0	0	0	0	0
457	0	0	0	0	0	0	0	0	0	0	0	0
458	0	0	0	0	0	0	0	0	0	0	0	0
459	0	0	0	0	0	0	0	0	0	0	0	0
460	2	2	2	2	2	2	0	0	0	0	0	0
461	0	0	0	0	0	0	0	0	0	0	0	0
462	3	3	5	5	5	5	1	0	2	0	3	4
463	1	1	2	2	2	2	2	0	0	2	2	2
464	1	1	2	2	2	2	2	0	0	0	0	2
465	0	0	0	0	0	0	0	0	0	0	0	0
466	0	0	0	0	0	0	0	0	0	0	0	0
467	3	3	6	6	6	6	6	0	6	6	6	6
468	0	0	0	0	0	0	0	0	0	0	0	0
469	0	0	0	0	0	0	0	0	0	0	0	0
470	0	0	0	0	0	0	0	0	0	0	0	0
471	0	0	0	0	0	0	0	0	0	0	0	0
472	2	2	5	5	5	2	5	0	5	2	5	5
473	0	0	0	0	0	0	0	0	0	0	0	0
474	0	0	0	0	0	0	0	0	0	0	0	0
475	0	0	0	0	0	0	0	0	0	0	0	0
476	0	0	0	0	0	0	0	0	0	0	0	0
477	1	1	2	2	2	2	2	0	0	0	1	2
478	1	1	2	2	2	2	2	0	0	0	0	2
479	2	2	3	3	3	3	3	0	1	0	3	3
480	0	0	0	0	0	0	0	0	0	0	0	0

TABLE I. (cont'd) MARSDEN SQUARE DATA DISTRIBUTION TABLE

DATA DISTRIBUTION BY MARSDEN SQUARE

MAR. SQ.	NUMBER STATIONS	SECCHI DEPTHS	TEMP	SAL	SIGMA-t	OXYGEN	PO_4	PHOS	NO_2	NO_3	SIL	pH
481	1	0	1	1	1	0	0	0	0	0	0	0
482	2	2	4	4	4	4	3	0	0	0	3	3
483	3	3	4	4	4	4	3	0	2	2	2	2
484	2	2	2	2	2	2	0	0	0	0	0	0
485	7	7	11	11	11	11	8	0	3	5	6	2
486	95	94	256	253	253	247	241	0	102	205	194	115
487	0	0	0	0	0	0	0	0	0	0	0	0
488	0	0	0	0	0	0	0	0	0	0	0	0
489	0	0	0	0	0	0	0	0	0	0	0	0
490	0	0	0	0	0	0	0	0	0	0	0	0
491	0	0	0	0	0	0	0	0	0	0	0	0
492	0	0	0	0	0	0	0	0	0	0	0	0
493	0	0	0	0	0	0	0	0	0	0	0	0
494	0	0	0	0	0	0	0	0	0	0	0	0
495	0	0	0	0	0	0	0	0	0	0	0	0
496	0	0	0	0	0	0	0	0	0	0	0	0
497	3	3	3	3	3	3	0	0	0	0	0	0
498	1	1	1	1	1	1	0	0	0	0	0	0
499	5	5	9	9	9	8	8	0	2	6	6	8
500	2	2	5	5	5	2	5	0	3	0	5	3
501	0	0	0	0	0	0	0	0	0	0	0	0
502	0	0	0	0	0	0	0	0	0	0	0	0
503	0	0	0	0	0	0	0	0	0	0	0	0
504	1	1	2	2	2	2	2	0	2	2	2	2
505	0	0	0	0	0	0	0	0	0	0	0	0
506	0	0	0	0	0	0	0	0	0	0	0	0
507	0	0	0	0	0	0	0	0	0	0	0	0
508	1	1	2	0	0	2	2	0	2	2	2	2
509	0	0	0	0	0	0	0	0	0	0	0	0
510	2	2	4	4	4	4	4	0	0	0	4	4
511	0	0	0	0	0	0	0	0	0	0	0	0
512	0	0	0	0	0	0	0	0	0	0	0	0
513	1	1	2	2	2	2	2	0	0	0	2	2
514	0	0	0	0	0	0	0	0	0	0	0	0
515	0	0	0	0	0	0	0	0	0	0	0	0
516	2	2	5	4	4	0	0	0	0	0	0	0
517	13	13	21	21	21	16	14	0	12	10	14	12
518	9	9	16	16	16	16	16	0	7	3	16	16
519	7	7	9	9	9	9	6	0	4	0	6	7
520	4	4	6	6	6	6	5	0	5	0	5	2
521	19	19	47	45	45	36	22	0	17	12	17	27
522	28	28	61	60	58	51	27	0	24	24	27	51
523	4	4	9	9	9	7	2	0	2	2	2	7
524	9	9	25	25	25	5	3	0	3	3	3	3
525	0	0	0	0	0	0	0	0	0	0	0	0
526	0	0	0	0	0	0	0	0	0	0	0	0
527	0	0	0	0	0	0	0	0	0	0	0	0
528	0	0	0	0	0	0	0	0	0	0	0	0
529	0	0	0	0	0	0	0	0	0	0	0	0
530	0	0	0	0	0	0	0	0	0	0	0	0
531	0	0	0	0	0	0	0	0	0	0	0	0
532	9	9	16	17	17	16	0	0	0	0	0	0
533	5	5	6	6	6	6	0	0	0	0	0	0
534	24	24	46	46	45	25	3	0	2	0	3	3
535	11	11	26	26	26	21	19	0	10	6	19	19
536	1	1	3	3	3	3	0	0	0	0	0	3
537	2	2	5	5	5	4	5	0	3	0	5	5
538	3	3	6	6	6	6	6	0	0	2	6	6
539	5	5	11	11	11	8	9	0	3	6	9	9
540	16	16	41	39	39	19	17	0	5	7	17	17

TABLE I. (cont'd) MARSDEN SQUARE DATA DISTRIBUTION TABLE

DATA DISTRIBUTION BY MARSDEN SQUARE

MAR. SQ.	NUMBER STATIONS	SECCHI DEPTHS	TEMP	SAL	SIGMA-t	OXYGEN	PO_4	PHOS	NO_2	NO_3	SIL	pH
541	9	9	20	16	16	10	4	0	0	0	4	4
542	9	9	23	23	23	20	18	0	3	0	18	13
543	2	2	4	4	4	4	4	0	0	0	4	4
544	7	7	16	15	15	16	13	0	0	0	13	16
545	3	3	8	8	8	4	8	0	6	1	8	8
546	5	5	12	12	12	10	12	0	6	0	12	12
547	3	3	5	6	6	6	4	0	2	0	4	6
548	3	3	7	7	7	7	2	0	0	0	2	2
549	4	4	9	9	9	9	6	0	2	0	6	6
550	3	3	8	8	8	2	1	0	2	0	2	8
551	0	0	0	0	0	0	0	0	0	0	0	0
552	0	0	0	0	0	0	0	0	0	0	0	0
553	6	6	11	11	11	11	8	0	2	2	8	8
554	12	12	23	24	23	24	20	0	6	6	20	19
555	16	16	29	29	29	29	24	0	18	13	24	23
556	10	10	21	18	18	9	8	0	7	4	8	5
557	2	2	3	3	3	3	0	0	0	0	0	0
558	0	0	0	0	0	0	0	0	0	0	0	0
559	0	0	0	0	0	0	0	0	0	0	0	0
560	0	0	0	0	0	0	0	0	0	0	0	0
561	1	1	3	3	3	3	0	0	0	0	0	0
562	1	1	2	2	2	2	0	0	0	0	0	0
563	0	0	0	0	0	0	0	0	0	0	0	0
564	0	0	0	0	0	0	0	0	0	0	0	0
565	0	0	0	0	0	0	0	0	0	0	0	0
566	0	0	0	0	0	0	0	0	0	0	0	0
567	4	4	8	8	8	0	0	0	0	0	0	0
568	26	26	66	66	66	29	0	0	0	0	0	0
569	25	25	67	68	67	48	21	0	0	0	0	0
570	64	64	194	190	189	154	53	0	0	0	0	0
571	55	55	169	166	165	83	16	0	0	0	0	0

TABLE I. (cont'd) MARSDEN SQUARE DATA DISTRIBUTION TABLE

Note: Chemistry data were obtained from NODC only if any Secchi depth data were on file for the Marsden square as of 9/25/72

TABLE II

AREA DELINEATION TABLE

AREA NO.	AREA ENCOMPASSED
1	Marsden Square 201
2	Marsden Square 200
3	Marsden Square 199
4	Marsden Square 167
5	Marsden Square 165
6	Latitude: 34°-38° (N) Longitude: 123°-127° (E)
7	Latitude: 30°-35° (N) Longitude: 135°-140° (E) Also included area bounded by: Latitude: 35°-36° (N) Longitude: 139°-140° (E)
8	Marsden Square 130
9	Marsden Square 129
10	Marsden Square 97
11	Marsden Square 96
12	Marsden Square 95
13	Marsden Squares 63 and 27
14	Marsden Square 62
15	Marsden Square 61
16	Marsden Square 60
17	Marsden Square 59

AREA NO.	AREA ENCOMPASSED
18	Marsden Square 24
19	Marsden Square 23
20	Marsden Square 22
21	Marsden Squares 360-361 Marsden Squares 396-397
22	Latitude: 60°-65° (N) Longitude: 160°-180° (W)
23	Marsden Square 198
24	Marsden Square 197
25	Marsden Square 196
26	Latitude: 49°-51° (N) Longitude: 144°-146° (W)
27	Marsden Square 193 Latitude: 50°-55° (N) Longitude: 130°-135° (W)
28	Latitude: 44°-48° (N) Longitude: 120°-126° (W)
29	Latitude: 0°-10° (S) Longitude: 70°-85° (W)
30	Marsden Square 343
31	Marsden Squares 413-414 Marsden Squares 449-450 Latitude: 50°-55° (S) Longitude: 60°-70° (W)
32	Marsden Square 43

TABLE II (Cont'd) AREA DELINEATION TABLE

AREA NO.	AREA ENCOMPASSED
33	Marsden Square 80
34	Marsden Square 115
35	Marsden Square 152
36	Marsden Square 186
37	Marsden Square 216
38	Marsden Squares 214,215,250 Latitude: 60°-65° (N) Longitude: 15°-20° (E)
39	Latitude: 40°-45° (N) Longitude: 15°-20° (E)
40	Latitude: 40°-45° (N) Longitude: 27°-45° (E)
41	Marsden Squares 142-143
42	Marsden Square 68
43	Latitude: 10°-20° (S) Longitude: 30°-48° (E)
44	Marsden Squares 327-328

TABLE II (Cont'd) AREA DELINEATION TABLE

AREA	DEP.	T	S	σ_t	O_2	PO_4	P_{tot}	NO_2	NO_3	SiO_4	LAT.	LONG	COL
1	.280	.207	.063	-.077	-.535	-.155				-.591	-.133	-.241	-.487
2	.400	.237	.215	-.218	-.379	.153				.093	-.105	.128	-.471
3	.016	.049	.060	.025	-.204	-.084		.044		.083	.863	.104	-.455
4	.400	.237	.215	-.218	-.379	.153				.093	-.105	.128	-.490
5	.280	.380	.555	-.306	-.401	-.340		-.642		.147	-.486	.018	-.517
6	.410	.548	-.114	-.486	-.605	-.123		-.152		-.102	.076	-.418	-.590
7	.621	.470	.511	.173	-.554	-.150	-.528	-.191	-.412	-.377	-.626	-.064	-.634
8	.477	.481	.309	-.232	-.428	-.210	-.842	-.121	-.425	-.136	-.353	-.223	-.560
9	.046	.506	-.069	-.521	-.469	-.293		.330	.017	-.140	-.226	-.003	-.557
10	.406	.149	.506	.350	.005	-.461		-.051	-.279	-.137	-.300	.175	-.799
11	.536	.479	.260	-.297	-.432	-.158	.821	-.150	-.010	.012	-.189	.255	-.531
12	.382	.578	-.252	-.565	-.426	-.189		-.072	-.261	-.251	-.144	.215	-.492
13	.639	.004	.553	.545	.291	-.371	-.069			-.455	-.714	-.687	-.821
14	.372	.348	.345	.098	.018	.007		.432		-.400	.041	.193	-.652
15	.058	.274'	-.007	-.237	-.782					.619	.029	.120	-.480
16	.359	.251	.129	-.158	-.206	.050		.103	.208	-.063	-.332	.347	-.394
17	.064	.291	-.019	-.037	-.527	-.129		.247	-.138	-.670	-.030	-.044	-.055
18	.346	.226	.024	-.132	-.029	.082		.764	-.547	.105	.384	.031	-.315
19	.169	.120	-.133	-.181	-.392	-.192		-.084	-.134	-.059	.292	.138	-.186

TABLE III. PARAMETER CORRELATION COEFFICIENT SUMMARY

AREA	DEP.	T	S	σ_t	O_2	PO_4	P_{tot}	NO_2	NO_3	SiO_4	LAT.	LONG	COL
20	-.116	.374	-.192	-.419	.077	-.341				-.201	.115	-.189	-.018
21	.504	.267	-.181	-.268	-.565	-.333		-.115	-.050	-.223	-.183	-.367	-.624
22	.181	.287	.083	.009	.317	.008				-.167	-.174	.381	-.456
23	.002	-.395	.120	.330	-.220	.169		-.129		.136	-.020	.128	-.482
24	.244	-.146	.091	.159	-.049	.507		.093	.674	.046	-.027	.065	-.342
25	.691	-.603	.638	.683	-.486	.493		.150	.738	.106	-.679	.425	
26	.027	-.443	.226	.433	.329	-.142		.615	.560	.442	-.017	.023	
27													
28	.610	.148	.504	.490	-.324	-.192			-.203	-.591	-.254	.601	-.598
29	.262	.166	-.051	-.156	-.114	-.076		-.161	.037	-.372	-.463	.401	
30	.430	.257	.210	-.253	-.004	-.074		.150	.000	-.026	.332	.212	
31	.069	-.073	.278	.237	-.036	.085		-.056	.227	-.122	.027	-.104	-.361
32	.594	.393	.061	-.054	.195	-.097	-.121	-.212	-.027	-.241	.425	.267	-.055
33	.138	.046	.079	-.006	-.067					.000	.056	.182	.172
34	.294	.698	.517	-.508	-.251	-.082	-.238	.172	-.171	-.166	-.401	-.404	-.618
35	-.059	.346	.215	-.064	-.265	-.530	-.065	.486	.763	.521	-.381	.348	.278
36	.427	-.662	.812	.808	-.170	-.216					.051	-.758	
37	.300	.203	.044	-.010	.085						.639	.165	
38	.337	-.084	.136	.145	.091	.058		-.065	.347	.296	-.106	-.308	-.210

TABLE III. PARAMETER CORRELATION COEFFICIENT SUMMARY (Cont'd)

AREA	DEP.	T	S	σ_t	O_2	PO_4	P_{tot}	NO_2	NO_3	SiO_4	LAT.	LONG	COL
39	.399	.249	.519	.424	-.441	-.004	-.175		.390	-.525	-.931	-.173	-.759
40	.547	.115	.524	.364	-.234						-.693	.292	
41	.345	.651	.229	-.486	-.544	-.092			-.075	-.166	-.19[illegible]	-.127	-.354
42	.583	.360	-.453	-.743	-.408	.063		-.993		.063	.075	.380	-.758
43	.508	.278	-.037	-.250	-.230	-.058			.392	-.322	-.408	.485	-.803
44	.002	-.170	-.028	.081	.375	-.132	.114	-.023	.280	-.496	-.056	-.007	.034

TABLE III. PARAMETER CORRELATION COEFFICIENT SUMMARY .(Cont'd)

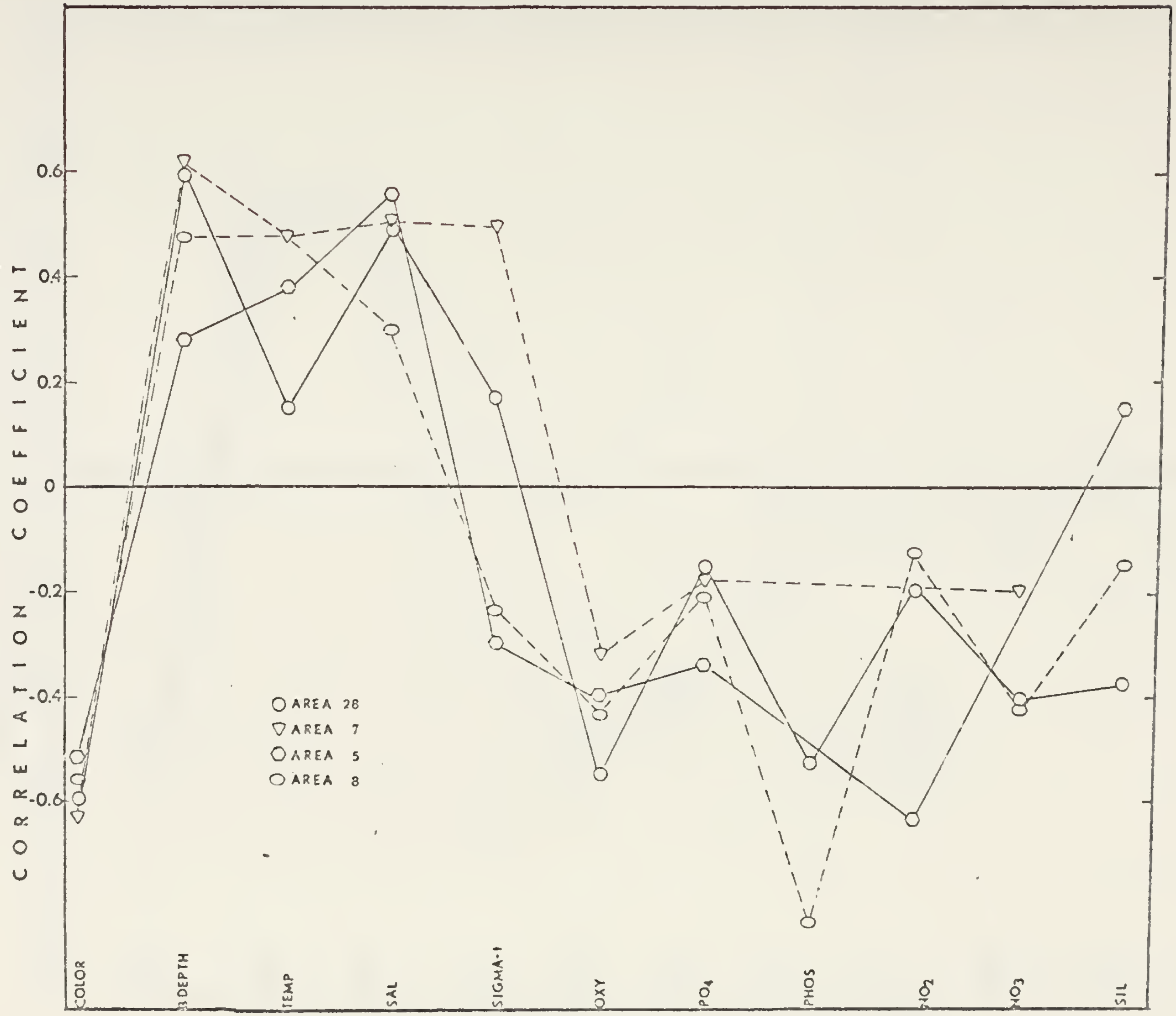


Figure 2A Correlation Coefficient Graph

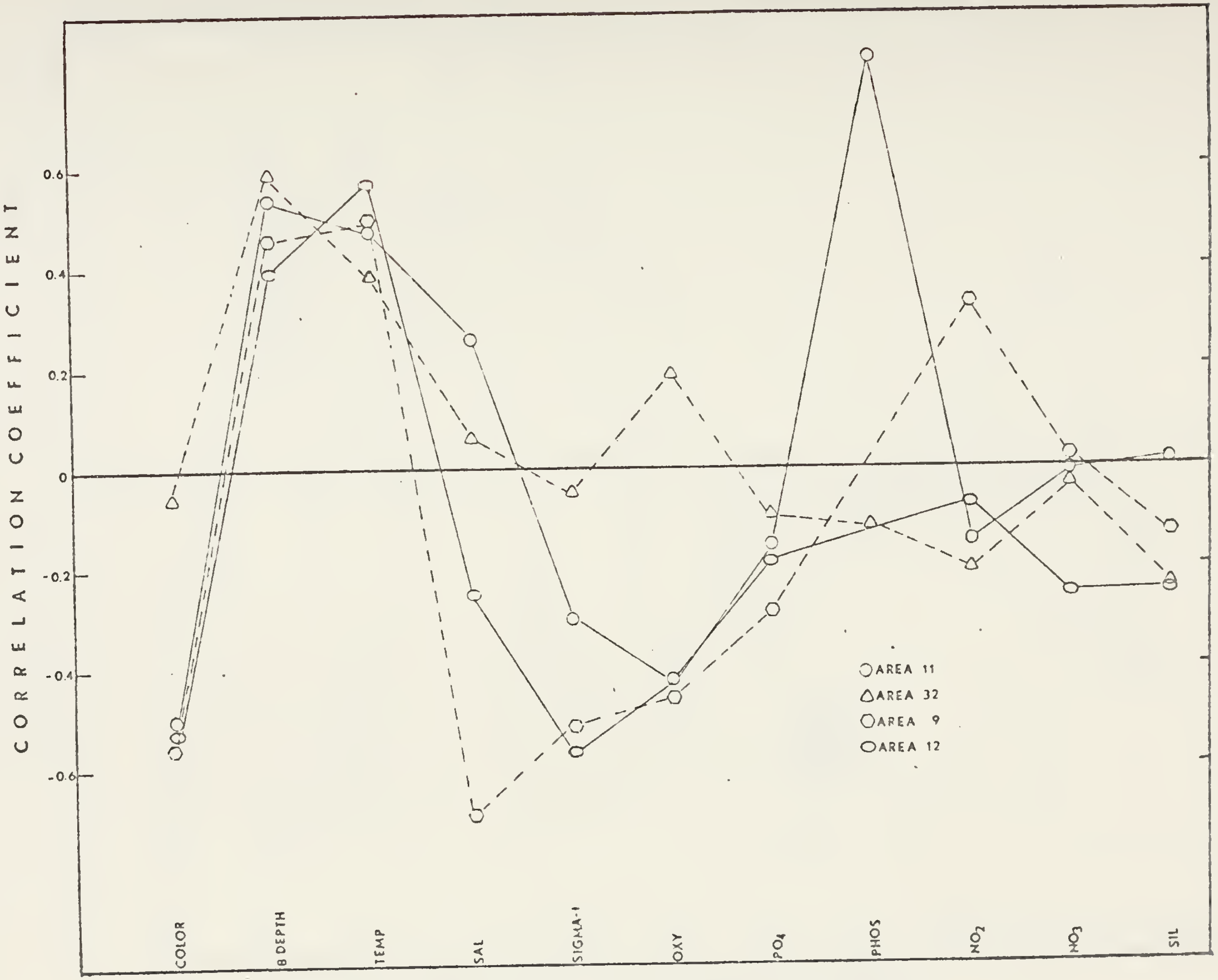


Figure 2B Correlation Coefficient Graph

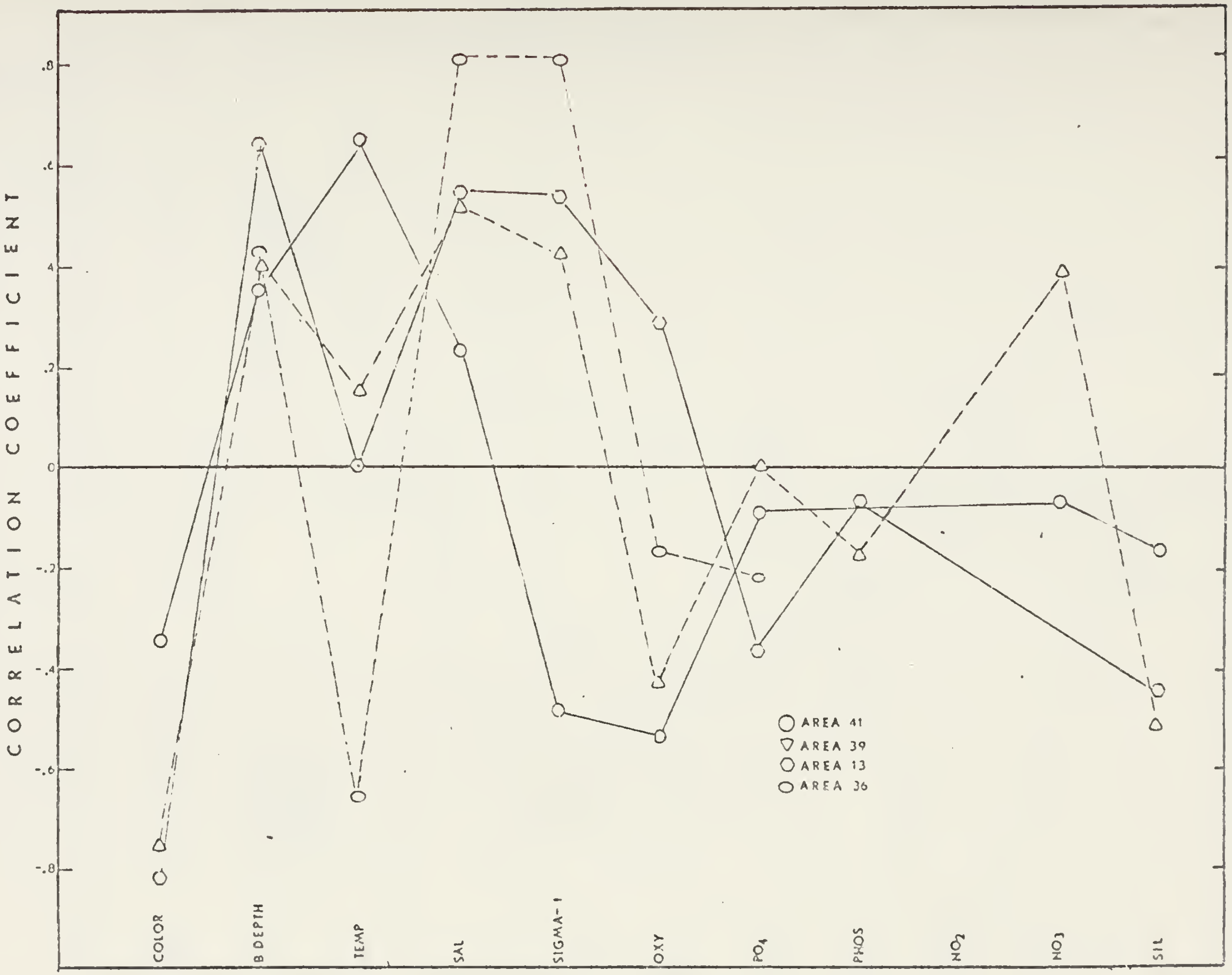


Figure 2C Correlation Coefficient Graph

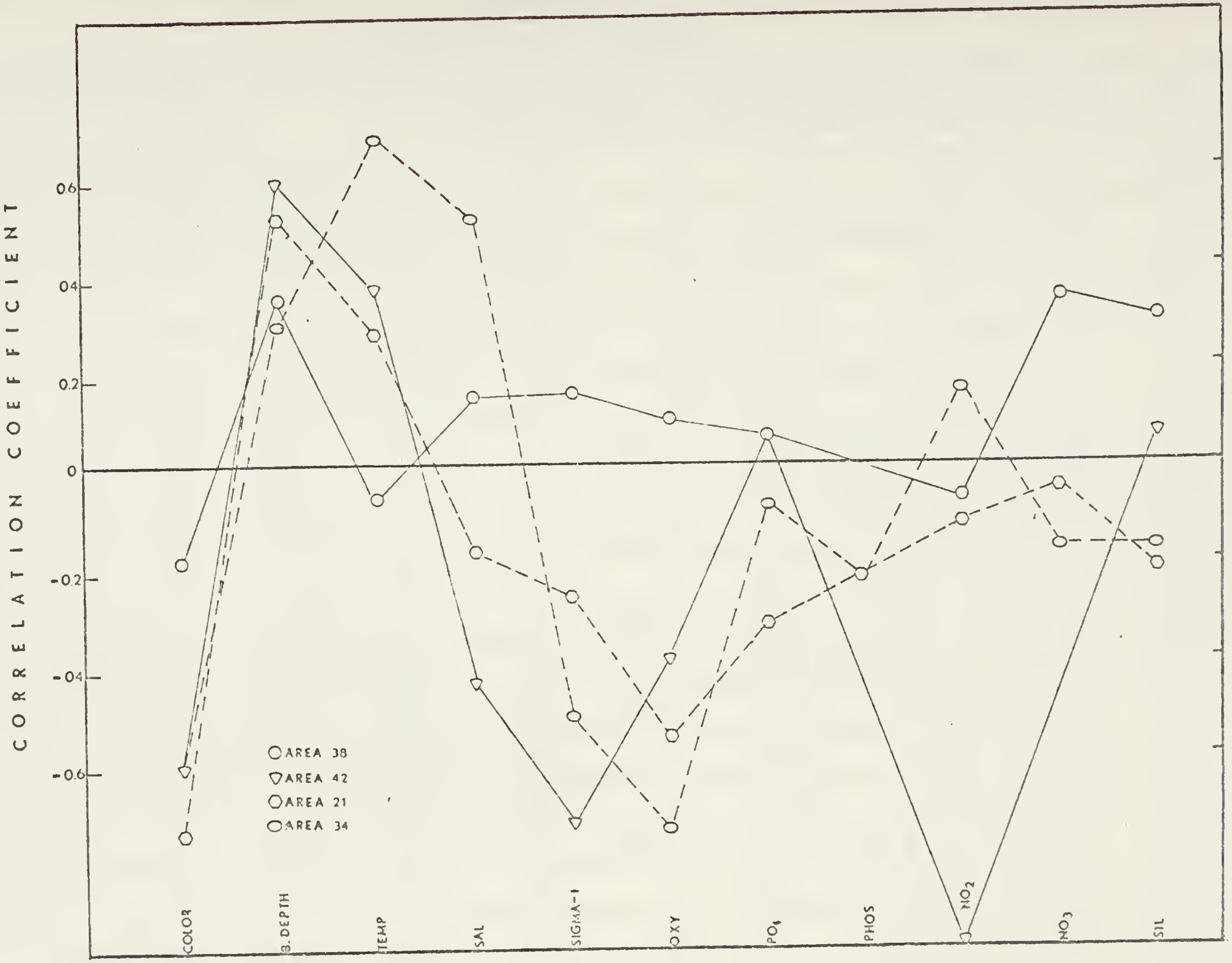


Figure 2D Correlation Coefficient Graph

TABLE IV

PARAMETER MEAN SUMMARY

AREA NO.	BOTTOM DEPTH (m)	TEMP (°C)	SALIN (°/oo)	SIGMA-t	OXYGEN (ml/l)	(PO_4) (µg-at/l)	PHOS (µg-at/l)	NITRITE (µg-at/l)	NITRATE (µg-at/l)	SIL (µg-at/l)	LAT (deg)	LONG (deg)	COLOR (FOREL-ULE)
1	248.0	6.7	32.5	25.42	7.14	.59				10.4	53.3	155.1	5.2
2	2295.0	8.1	32.4	25.17	7.14	1.16		.02	17.53	42.9	54.0	12.0	12.0
3	2270.0	6.7	33.0	25.88	7.32	1.68		.02		33.7	54.0	175.0	4.0
4	1208.0	13.1	34.8	25.13	5.97	.32				8.1	42.0	135.0	4.0
5	3250.0	12.5	33.1	24.90	6.67	.84		.59	7.30	15.0	44.0	154.0	5.0
6	60.9	15.0	31.9	23.30	5.58	.34		.09		14.2	36.3	125.2	5.5
7	1295.0	20.9	33.5	23.31	5.38	.21	.45	.08	2.22	13.3	33.6	137.6	3.2
8	2388.5	19.7	34.1	24.04	5.48	.28	.15	.15	3.03	8.3	35.9	143.0	3.1
9	5612.9	19.4	34.3	24.35	5.64	.22	2.37	.12	.49	7.4	37.9	153.2	2.7
10	821.8	27.8	33.3	21.12	4.54	.54		.26	2.32	7.4	22.2	117.9	3.2
11	1627.9	25.4	34.3	22.68	4.78	.25	1.28	.23	1.65	7.9	25.9	125.3	2.4
12	3772.3	24.9	34.6	23.03	4.95	.15		.11	7.52	7.9	28.0	134.1	2.0
13	551.9	28.7	32.3	20.15	4.41	.25	.48		.70	5.1	7.7	97.4	3.7
14	61.9	27.2	32.7	21.01	4.71	.20		.12		1.4	18.0	108.0	4.2
15	2243.2	28.0	33.6	21.26	4.58	.10				5.0	15.6	114.6	2.4
16	4263.6	28.3	34.3	21.81	4.57	.16	1.08	.04	.26	5.9	15.7	125.5	2.1
17	5231.7	28.0	34.5	22.02	4.65	.21		.06	.16	8.0	14.6	134.9	1.7
18	4264.3	28.7	34.2	21.60	4.54	.20		.06	.20	9.3	5.0	125.9	2.0
19	4404.6	28.7	34.3	21.64	4.54	.20		.05	.48	7.5	5.9	134.5	1.8

TABLE IV (Cont'd)

PARAMETER MEAN SUMMARY

AREA NO.	BOTTOM DEPTH (m)	TEMP (°C)	SALIN (°/oo)	SIGMA-t	OXYGEN (ml/l)	(PO_4) (μg-at/l)	PHOS (μg-at/l)	NITRITE (μg-at/l)	NITRATE (μg-at/l)	SIL (μg-at/l)	LAT (deg)	LONG (deg)	COLOR (FOREL-ULE)
20	3414.9	28.8	34.5	21.78	4.49	.15	.63	.05	.7	8.3	5.6	144.7	2.0
21	2124.0	26.7	34.8	22.64	4.84	.19	.47	.03	.29	6.5	15.8	112.6	2.3
22	57.3	6.9	31.2	24.39	6.75	.70				8.5	63.2	171.8	5.1
23	1122.2	6.6	32.8	25.73	7.09	1.35		.07		24.8	55.4	175.2	4.9
24	148.7	7.3	31.8	24.87	7.01	.99		.10	.65	14.5	56.4	164.4	5.7
25	910.6	9.4	30.4	23.42	7.32	1.21		.21	7.72	27.5	57.7	152.4	
26	4027.0	8.5	32.7	25.36	6.89	1.46		.18	13.6	23.3	50.0	145.0	4.0
27	317.7	12.4	20.6	15.44	7.01	1.08		.11	6.97	21.8	51.7	127.7	11.0
28	592.6	13.1	28.3	21.39	6.42	.67			3.66	25.1	46.0	124.6	9.5
29	1048.9	21.2	34.7	24.25	4.73	1.0		.15	7.77	21.2	5.7	81.7	
30	1254.6	18.4	35.0	25.19	4.93	1.26		.73	10.76	11.1	14.0	76.5	
31	850.8	11.8	33.6	25.45	6.25	.96	.02	.15	6.40	7.0	43.0	58.9	11.1
32	931.8	26.2	35.6	23.44	4.01	.52	1.41	.20	3.12	11.4	12.0	64.1	3.0
33	2539.6	26.5	36.3	23.91	4.65	.20				3.0	26.2	76.9	1.5
34	3843.2	24.2	36.1	24.34	4.83	.07	.26	.09	.41	1.2	34.8	65.4	2.9
35	56.1	15.3	30.7	22.33	5.70	.53	.80	.13	3.28	3.4	41.4	71.4	9.5
36	302.8	10.9	17.0	13.01	7.10	.50		.05		17.0	53.9	58.0	
37	109.5	10.0	32.9	25.24	6.46						55.5	4.8	
38	67.7	10.3	6.8	4.89	7.59	.22		.12	.90	21.6	59.1	20.0	12.4

TABLE IV (Cont'd)

PARAMETER MEAN SUMMARY

AREA NO.	BOTTOM DEPTH (m)	TEMP (°C)	SALIN (°/oo)	SIGMA-t	OXYGEN (ml/l)	(PO_4) (µg-at/l)	PHOS (µg-at/l)	NITRITE (µg-at/l)	NITRATE (µg-at/l)	SIL (µg-at/l)	LAT (deg)	LONG (deg)	COLOR (FOREL-ULE)
39	99.2	17.8	36.8	26.39	5.54	.02	.21	.02	.14	34.9	43.1	16.4	2.4
40	315.7	19.8	16.3	10.54	5.48						44.5	33.8	
41	1475.9	19.0	38.4	27.57	5.23	.12		.09	.45	2.6	36.4	21.3	2.4
42	581.7	28.7	36.5	23.22	4.31	.24		.14	3.80	11.4	12.4	44.9	2.2
43	2012.5	26.5	34.9	22.85	4.68	.14		.03	.13	3.5	15.9	40.8	4.3
44	4939.9	28.3	34.5	21.92	4.50	.27	.97	.04	.17	4.3	4.8	83.5	1.6

Area	Number Data Pts.	Range Z_s (m)	First Parameter Selected	Parameter Range	R	Second	Parameter Range	R	Third	Parameter Range	R
2	172	2-30	SALINITY	31.5-33.4[‰]	.53						
			$Z_s = [.5 + 18.0\ (SAL)^{-1}]^{-1}$								
2	100	2-23	COLOR	2-10	.55	TEMP	.5-13.8 [°C]	.72	SALINITY	23.5-33.2 [‰]	.77
			$Z_s = -11.0 + 48.9\ (COL)^{-\frac{1}{2}}$			$Z_s = -12.0 + 47.97\ (COL)^{-\frac{1}{2}} + 7.15\ (T)^{-1}$			$Z_s = -38.4 + .9\ (SAL) + 40(COL)^{-\frac{1}{2}} + 6.8\ (T)^{-1}$		
4	637	11-22	COLOR	2-6	.47	SALINITY	33.0-34.9 [‰]	.55	COLOR	2-6	.55
			$Z_s = 27.3 - 2.8\ (COL)$			$Z_s = -69.35 - 2.64\ (COL) + 2.8\ (SAL)$			$Z_s = -79.5 - 1.9\ (COL) + 2.9\ (SAL) + 10.9\ (COL)^{-\frac{1}{2}}$		
5	132	8-25	COLOR	2-10	.55	OXYGEN	4.55-8.90 [ml/l]	.59	SIGMA-t	23.00-26.70	.65
			$Z_s = 3.9 + 42.6\ (COL)^{-1}$			$Z_s = 14.2 - .0001\ (OXY) + 3.59(COL)^{-1}$			$Z_s = -24.7 + 2\ (SIG) - 3(OXY) + 33.2\ (COL)^{-1}$		

TABLE V LINEAR REGRESSION ANALYSIS RESULTS

Area	Number Data Pts.	Range Z_s (m)	First Parameter Selected	Parameter Range	R	Second	Parameter Range	R	Third	Parameter Range	R
7 Run (d)	5190	1-40	SALINITY	7-33 [‰]	.79	TEMP	6-32 [°C]	.82			
			$Z_s = [1.3 - .04 (SAL)]^{-1}$			$Z_s^{-1} = 1.4 - .005 (T) - .04 (SAL)$					
9	899	9-44	SIGMA-t	22.10-26.70	.53	SIGMA-t	22.10-26.70	.56	OXYGEN	4.20-6.90 [ml/l]	.58
			$Z_s = -6.2 + 17.1 x 10^3 (SIG)^{-2}$			$Z_s = -423.2 + 11 (SIG) + 9.9 x 10^4 (SIG)^{-2}$			$Z_s = -504 + 14 (SIG) - 2 (OXY) + 1.1 x 10^5 (SIG)^{-2}$		
11	525	12-40	TEMP	14-30 [°C]	.47	SIGMA-t	20.00-26.00	.51	TEMP	14-30 [°C]	.55
			$Z_s = 41.9 - 420.6 (T)^{-1}$			$Z_s = 18.5 + 1.4 (SIG) - 617 (T)^{-1}$			$Z_s = -89.2 + 1.8 (T) + 3 (SIG) + 37.0 (T)^{-1}$		
12	211	11-32	TEMP	17.4-31.2 [°C]	.96	TEMP	17.4-31.2 [°C]	.99	SIGMA-t	21.50-24.00	.99
			$Z_s = 58.1 - 806.0 (T)^{-1}$			$Z_s = 81.5 - 2096.5 (T)^{-1} + 16991 (T)^{-2}$			$Z_s = 81.9 - 170 (SIG)^{-2} - 2102 (T)^{-1} + 17036 (T)^{-2}$		

TABLE V (Cont'd) LINEAR REGRESSION ANALYSIS RESULTS

Area	Number Data Pts.	Range Z_s (m)	First Parameter Selected	Parameter Range	R	Second	Parameter Range	R	Third	Parameter Range	R
6	1731	1-23	COLOR	2-15	.67						
			$Z_s = -1.5 + 47.9\ (COL)^{-1}$								
7 Run (a)	1086	1-40	COLOR	1-18	.65	COLOR	1-18	.72	TEMP	5.5-31.5 [°C]	.75
			$Z_s = -.73 + 35.0\ (COL)^{-\frac{1}{2}}$			$Z_s = -14.7 - 24.0\ (COL)^{-2} + 65.2\ (COL)^{-\frac{1}{2}}$			$Z_s = -13.0 - 21\ (COL)^{-2} + 55\ (COL)^{-\frac{1}{2}} + .01\ (T)^2$		
7 Run (b)	5190	1=40	SALINITY	6-36 [‰]	.56	TEMP	5.5-33.5 [°C]	.62			
			$Z_s^{-1} = -.2 + 9.7\ (SAL)^{-1}$			$Z_s^{-1} = -.3 + 1.8\ (T)^{-1} + 9.7\ (SAL)^{-1}$					
7 Run (c)	360	3-40	COLOR	1-12	.70	OXYGEN	4.30-8.50 [ml/l]				
			$\ell n(Z_s) = 3.7 - .24\ (COL)$			$\ell n(Z_s) = 5.1 - .17\ (COL) - .3\ (OXY)$					

TABLE V (Cont'd) LINEAR REGRESSION ANALYSIS RESULTS

Area	Number Data Pts.	Range Z_s (m)	First Parameter Selected	Parameter Range	R	Second	Parameter Range	R	Third	Parameter Range	R
13	71	3-40	DEPTH	100-4700[m]	.80	DEPTH	100-4700[m]	.85	SALINITY	31.7-33.9[‰]	
			$Z_s = 16.5 + .3(DEP)^{1/2}$			$Z_s = 11.0 + 1.1\ (DEP)^{1/2} - .01\ (DEP)$			$Z_s = -63.5 - .01\ (DEP) + 2.4\ (SAL) - (DEP)^{1/2}$		
21	53	0-40	DEPTH	13-7000[m]	.66	OXYGEN	4.26-6.00[ml/l]	.71			
			$Z_s = 21.7 + .002\ (DEP)$			$Z_s = 6.7 + .001\ (DEP) + 410\ (OXY)^{-2}$					
25	45	1-25	TEMP	3.3-12.2[°C]	.76	DEPTH	16-5158[m]	.85	SALINITY	19-33.3[‰]	.88
			$Z_s = .97 + 64.3\ (T)^{-1}$			$Z_s = .85 + .001\ (DEP) + 49.1\ (T)^{-1}$			$Z_s = -11.0 + .001\ (DEP) + 43.2\ (T) + .01\ (S)^2$		
28 Run (a)	202	1-14	COLOR	2-18	.60	SALINITY	4.3-32.2 [‰]	.63			
			$Z_s = 15.7 - .7\ (COL)$			$Z_s = 9.4 - .5\ (COL) + .005\ (S)^2$					

TABLE V (Cont'd) LINEAR REGRESSION ANALYSIS RESULTS

Area	Number Data Pts.	Range Z_s (m)	First Parameter Selected	Parameter Range	R	Second	Parameter Range	R	Third	Parameter Range	R
28 Run (b)	358	1-17	SILICATE	0-120 $[\frac{\mu g\text{-}at}{\ell}]$	.79						
			$Z_s^{-1} = .06 + .007\,(SIL)$								
29	81	1-31	SILICATE	0-93 $[\frac{\mu g\text{-}at}{\ell}]$	.43	OXYGEN	1.50-8.40[ml/1]		PHOS	.02-3.5 $[\frac{\mu g\text{-}at}{\ell}]$	
			$Z_s = 22.5 - 2.3(SIL)^{\frac{1}{2}}$			$Z_s = 28.2 - (OXY) - 2.1\,(SIL)^{\frac{1}{2}}$			$Z_s = 34.4 - 2.3(OXY) - 2.3(PHOS) - 1.9(SIL)^{\frac{1}{2}}$		
32	49	5-34	NITRITE	.04-.50 $\frac{\mu g\text{-}at}{\ell}$	.36	SILICATE	1-34 $\frac{\mu g\text{-}at}{\ell}$	.46	OXYGEN	2.60-5.50 ml/1	.54
			$Z_s = 9.4 + .4\,(NIT)^{-1}$			$Z_s = 7.2 + .4\,(NIT)^{-1} + 14.6\,(SIL)^{-1}$			$Z_s = 16.0 - 3\,(OXY) + .46(NIT)^{-1} + 16.7\,(SIL)^{-1}$		
34	69	10-40	OXYGEN	4.00-7.00 ml/l	.75	OXYGEN	4.00-7.00 ml/1	.78	SALINITY	34.5-37.0	.79
			$Z_s = 77.7 - 10\,(OXY)$			$Z_s = 151.4 - 20\,(OXY) - 640.1\,(OXY)^{-2}$			$Z_s = 82.7 - 15\,(OXY) + .03\,(S)^2 - 420\,(OXY)^{-2}$		

TABLE V (Cont'd) LINEAR REGRESSION ANALYSIS RESULTS

Area	Number Data Pts.	Range Z_s (m)	First Parameter Selected	Parameter Range	R	Second	Parameter Range	R	Third	Parameter Range	R
35	1259	1-60	TEMP	1.2-25.2	.36	SALINITY	1.0-33.1 [°/₀₀]	.42	TEMP	1.2-25.2[°C]	.44
			$Z_s = 4.12 + .02\ (T)^2$			$Z_s = -18.0 + .02\ (T)^2 + .02\ (S)^2$			$Z_s = -12.8 - 1.4\ (T) + .07\ (T)^2 + .02\ (S)^2$		
36	255	2-27	SALINITY	1.2-35.1[°/₀₀]	.85	TEMP	1.2-19.1[°C]	.86	SALINITY	1.2-35.1 [°/₀₀]	.86
			$Z_s = 2.2 + .01\ (S)^2$			$Z_s = -1.9 + .3\ (T) + .01\ (S)^2$			$Z_s = 7.9 + .02\ (DEP) + .07\ (S) - (1.9\ (S)^{-1}$		
38	765	1-18	DEPTH	3-200[m]	.33	DEPTH	3-200[m]	.42	SALINITY	.4-34.1 [°/₀₀]	.43
			$Z_s = 8.0 + .02\ (DEP)$			$Z_s = 8.6 + .02\ (DEP) - 2.3\ (SAL)^{-1}$			$Z_s = 7.9 + .02\ (DEP) + .07\ (S) - 1.9\ (S)^{-1}$		
39 Run (a)	228	2-38	OXYGEN	4.2-7.5[ml/l]	.44	PHOS	.03-.6[$\frac{\mu g\text{-at}}{\ell}$]	.47			
			$Z_s = -20.9 + 217\ (OXY)^{-1}$			$Z_s = -16.0 - 13\ (PHOS) + 206\ (OXY)^{-1}$					

TABLE V (Cont'd) LINEAR REGRESSION ANALYSIS RESULTS

Area	Number Data Pts.	Range Z_s (m)	First Parameter Selected	Parameter Range	R	Second	Parameter Range	R	Third	Parameter Range	R
39 Run (b)	922	2-42	SALINITY	26.2-39.4	.61						
			$Z_s = [.053\ \ .33\ (S)^{-1}]^{-1}$								
41	45	3-49	COLOR	1-4	.35	OXYGEN	4.50-5.84[ml/l]	.41	OXYGEN	4.50-5.84[ml/l]	.44
			$Z_s = 45.4 - 4.8\ (COL)$			$Z_s = 78.9 - 4.0\ (COL) - 7\ (OXY)$			$Z_s = 1013.7 - 3.4\ (COL) - 100\ (OXY) - 2356\ (OXY)^{-1}$		
42	18	4-32	SIGMA-t	22.0-24.5	.56	OXYGEN	3.2-5.2[ml/l]	.60			
			$Z_s = 242.9 - 10\ (SIG)$			$Z_s = 247.1 - 9.2\ (SIG) - 91\ (OXY)^{-2}$					

TABLE V (Cont'd) LINEAR REGRESSION ANALYSIS RESULTS

TABLE VI
GRAPH DATA DENSITY CODE

This following table shows the symbol representations used in plotting frequencies of data in BIOMED 02D graphical output.

NO. POINTS	SYMBOL	NO. POINTS	SYMBOL
1	1	21	L
2	2	22	M
3	3	23	N
4	4	24	O
5	5	25	P
6	6	26	Q
7	7	27	R
8	8	28	S
9	9	29	T
10	A	30	U
11	B	31	V
12	C	32	W
13	D	33	X
14	E	34	Y
15	F	35	Z
16	G	36-41	-
17	H	42-47	+ (&)
18	I	48-54	*
19	J	55-62	$
20	K	63+	/

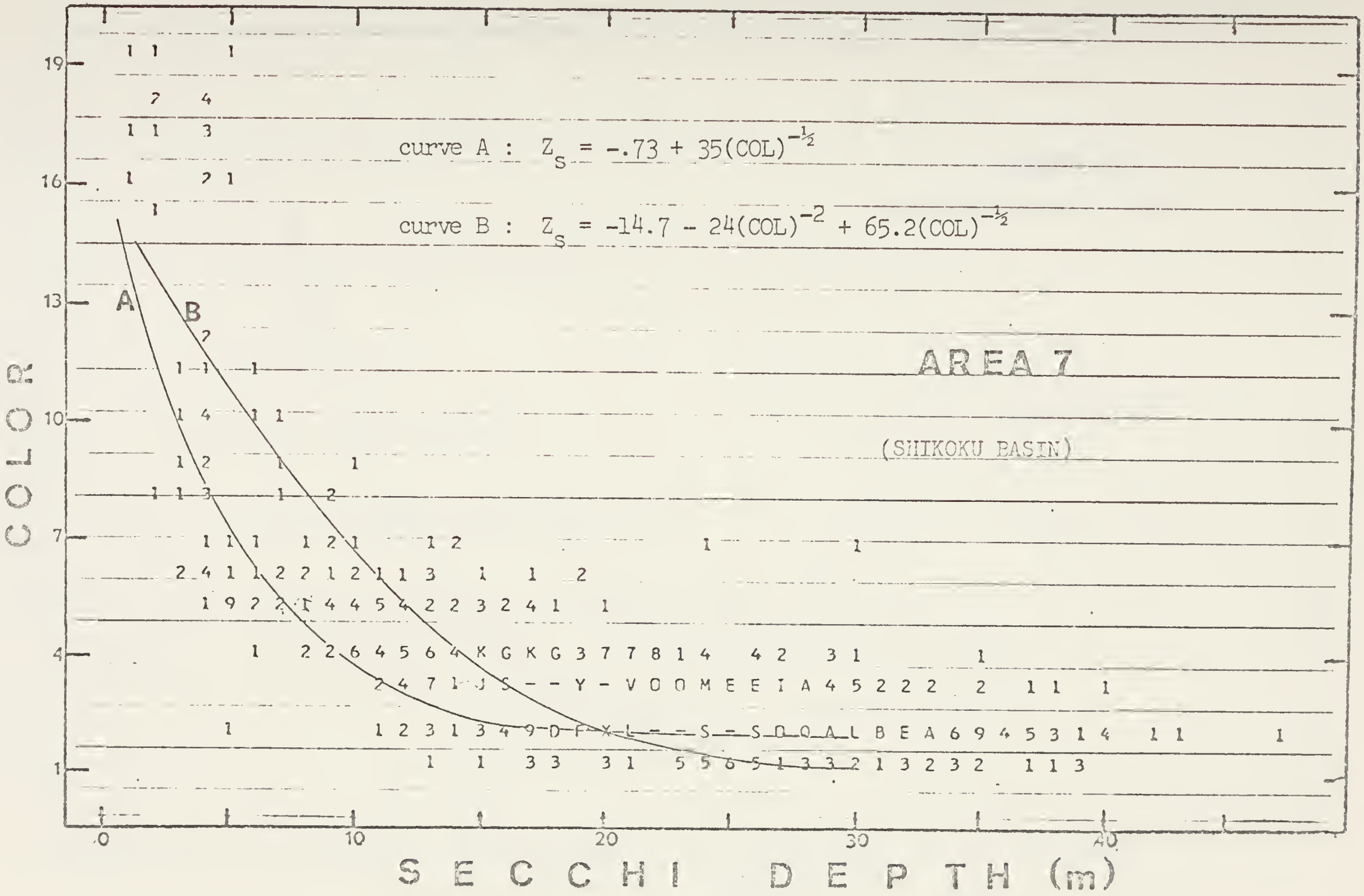

curve A : $Z_s = -.73 + 35(COL)^{-\frac{1}{2}}$
curve B : $Z_s = -14.7 - 24(COL)^{-2} + 65.2(COL)^{-\frac{1}{2}}$
AREA 7
(SHIKOKU BASIN)
A
B
COLOR
19
16
13
10
7
4
1
0
10
20
30
40
SECCHI DEPTH (m)

Figure 3.

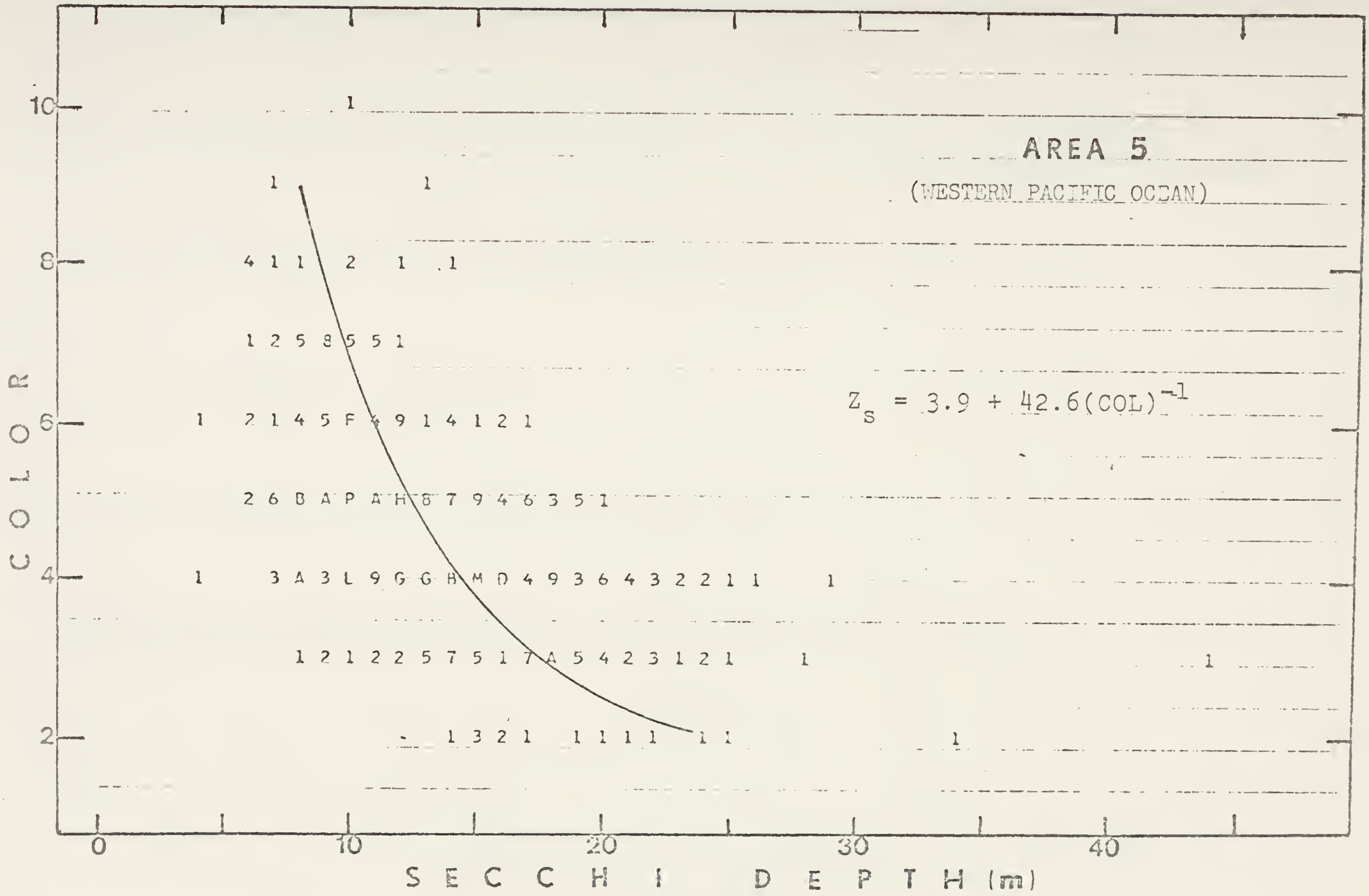

AREA 5
(WESTERN PACIFIC OCEAN)
$Z_s = 3.9 + 42.6(\mathrm{COL})^{-1}$
COLOR
SECCHI DEPTH (m)
0
10
20
30
40
2
4
6
8
10

Figure 4.

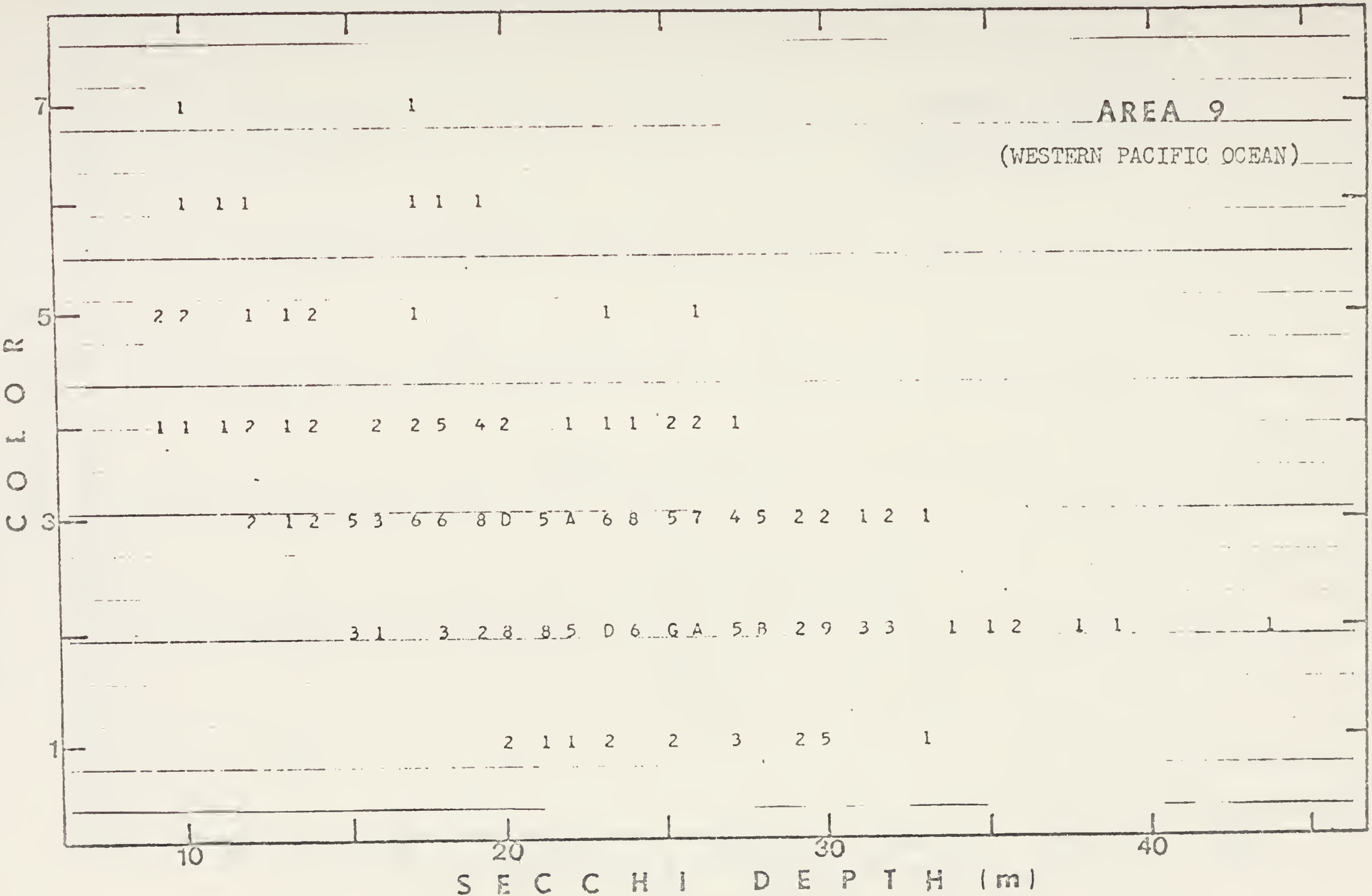
AREA 9
(WESTERN PACIFIC OCEAN)
COLOR
7
5
3
1
10
20
30
40
SECCHI DEPTH (m)

Figure 5.

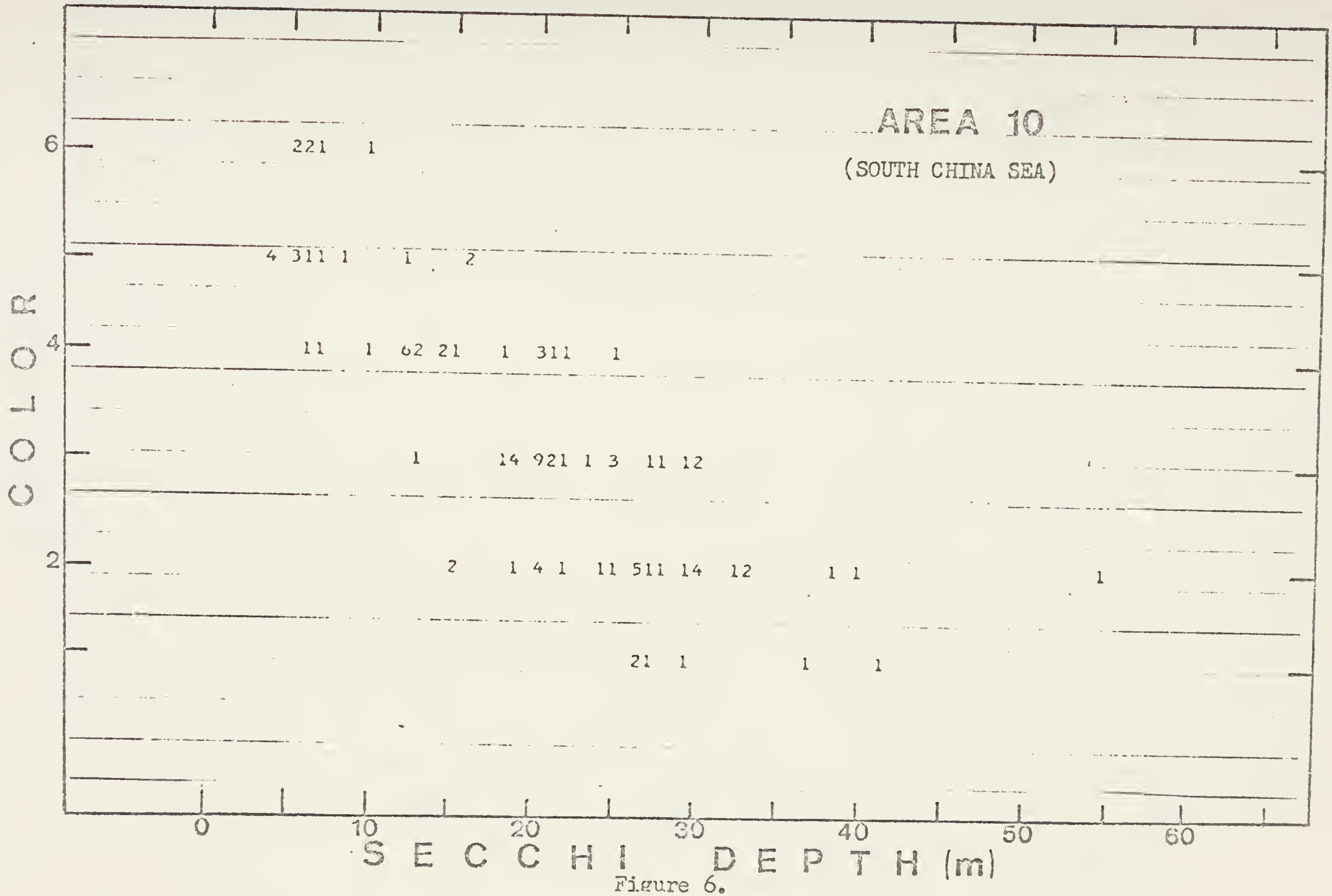

AREA 10
(SOUTH CHINA SEA)
COLOR
6
4
2
0
10
20
30
40
50
60
SECCHI DEPTH (m)
221 1
4 311 1 1 2
11 1 62 21 1 311 1
1 14 921 1 3 11 12
2 1 4 1 11 511 14 12 1 1 1
21 1 1 1

Figure 6.

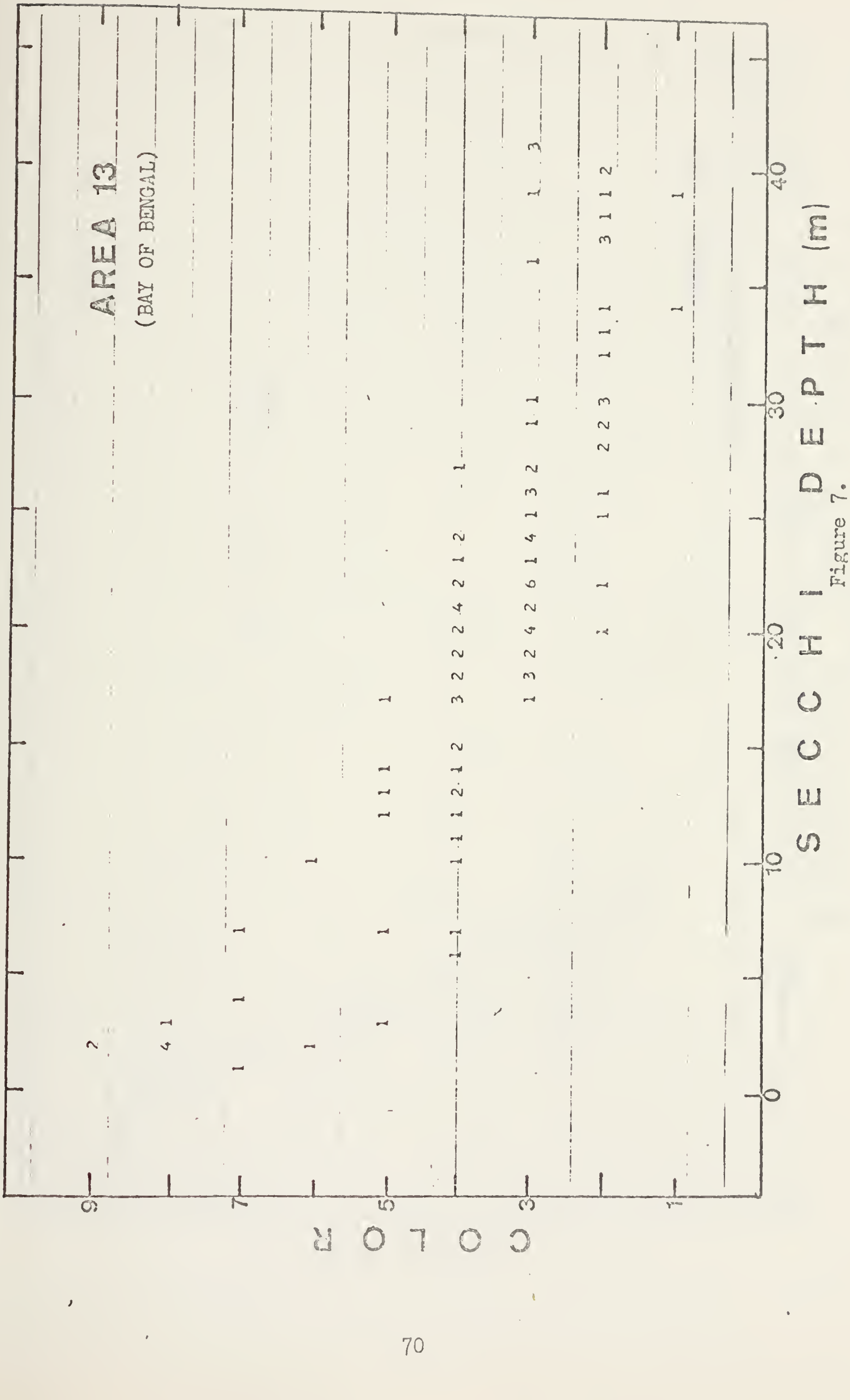

AREA 13
(BAY OF BENGAL)
COLOR
SECCHI DEPTH (m)
9
7
5
3
1
0
10
20
30
40
2
4 1
1 1 1 1
1 1
1 1 1 1 1 1 1
1 1 1 1 1 2 1 2 3 2 2 4 2 1 2 1
1 3 2 4 2 6 1 4 1 3 2 1 1 1 1 3
1 1 1 1 2 2 3 1 1 1 3 1 1 2
1 1

Figure 7.

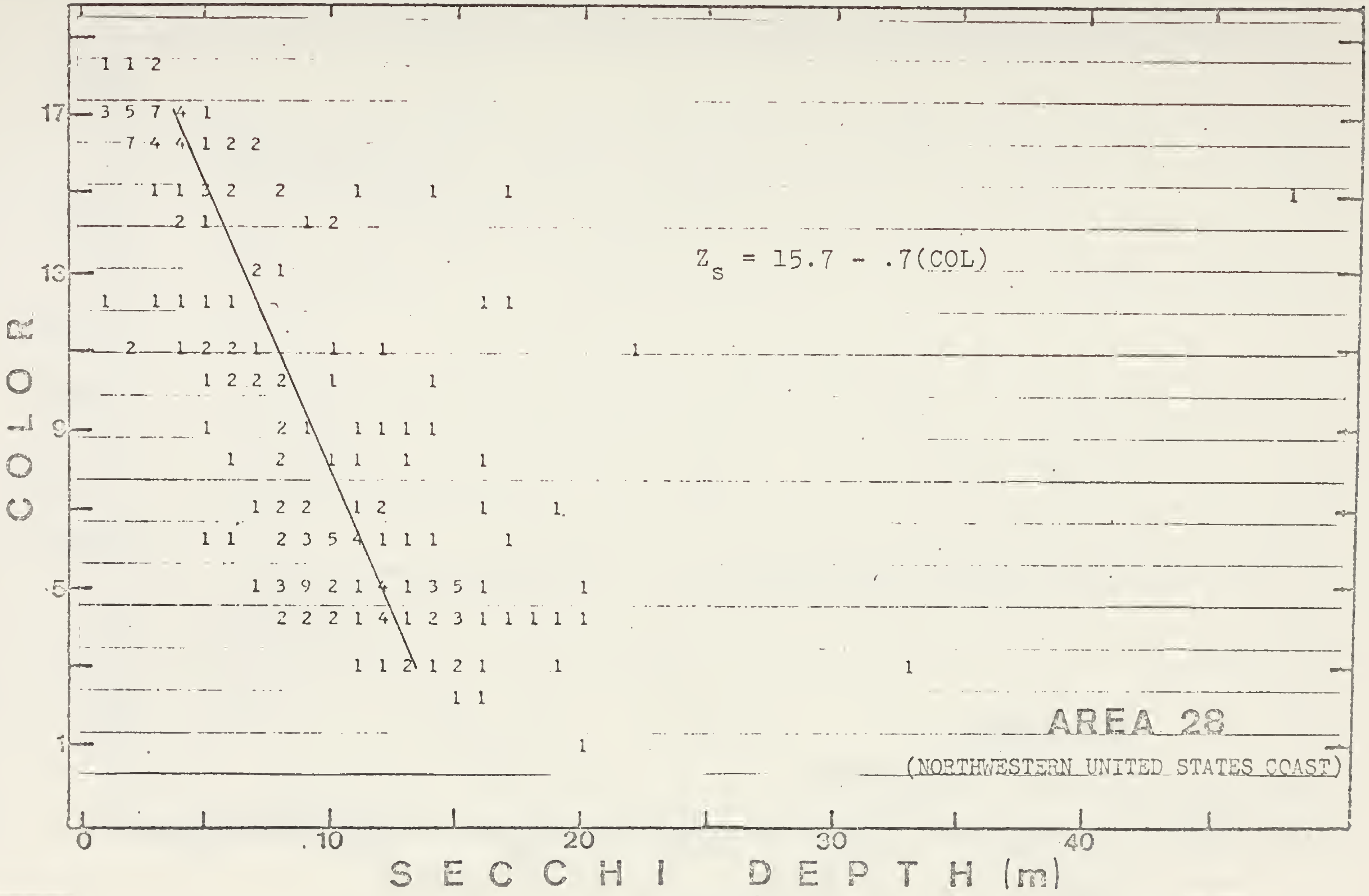

COLOR
17
13
9
5
1
0
10
20
30
40
SECCHI DEPTH (m)
$Z_s = 15.7 - .7(\mathrm{COL})$
AREA 28
(NORTHWESTERN UNITED STATES COAST)

Figure 8.

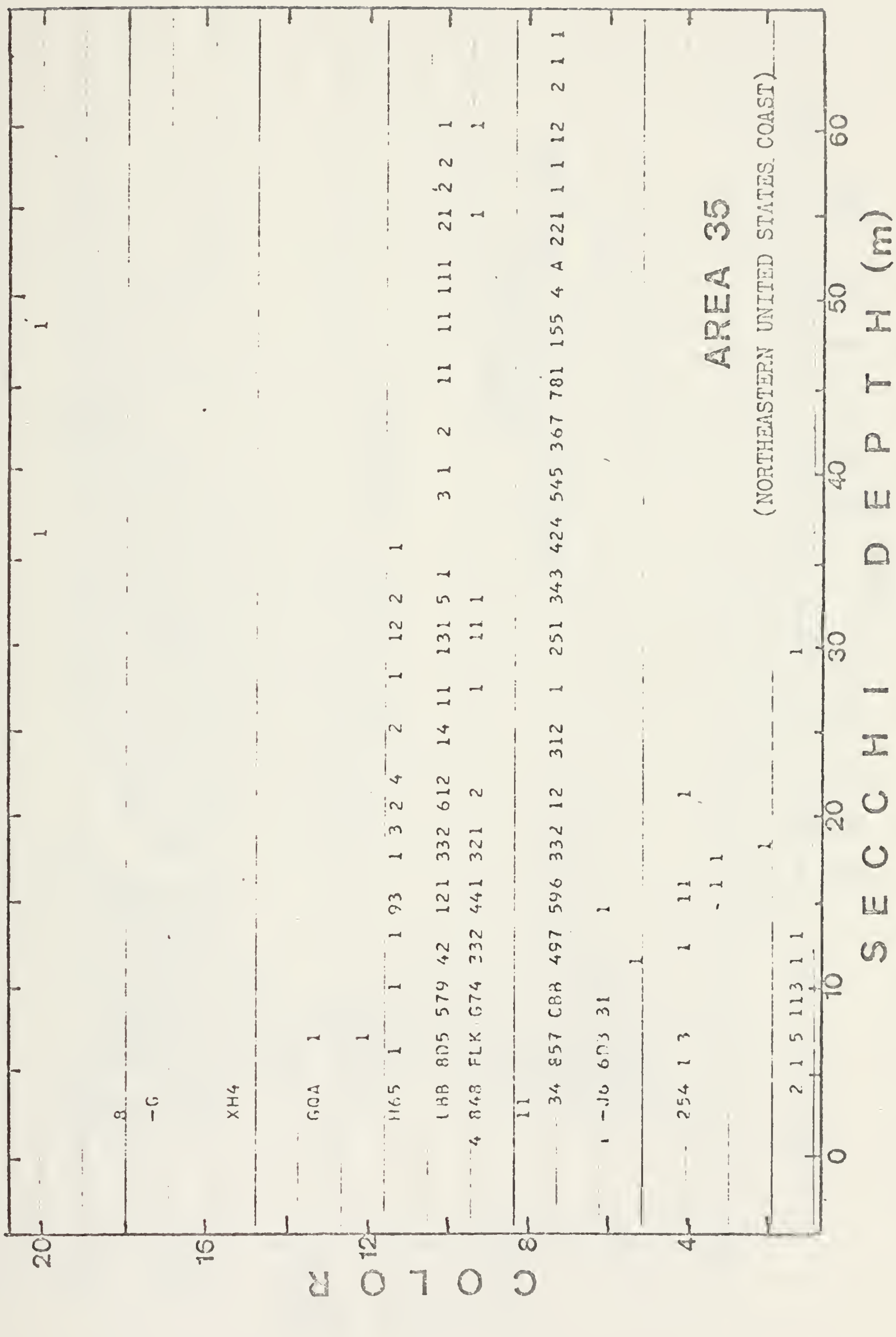
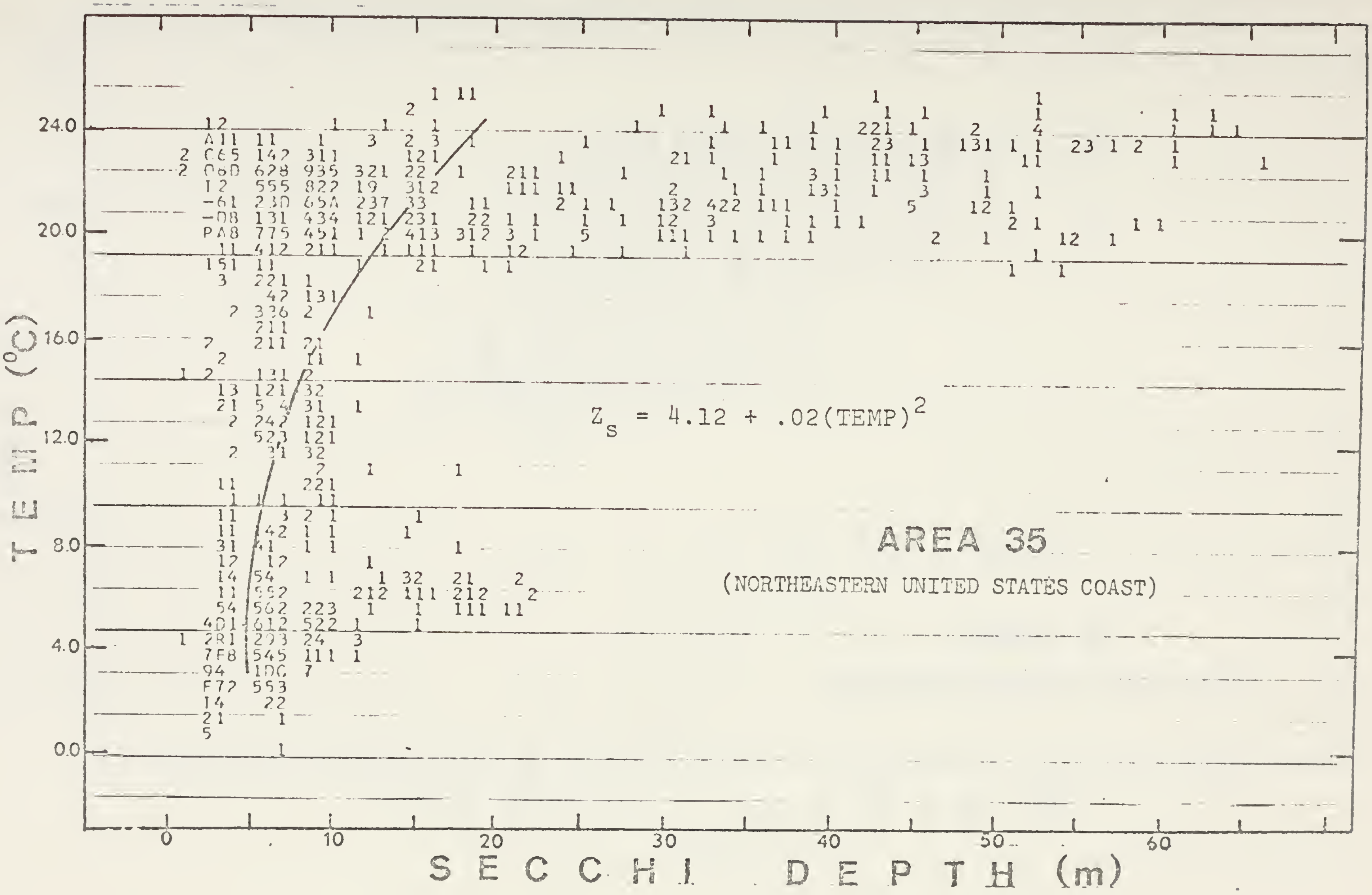

AREA 35
(NORTHEASTERN UNITED STATES COAST)
SECCHI DEPTH (m)
COLOR
0
10
20
30
40
50
60
4
8
12
16
20

Figure 9.



24.0
20.0
16.0
12.0
8.0
4.0
0.0
TEMP (°C)
0
10
20
30
40
50
60
SECCHI DEPTH (m)
Z_s = 4.12 + .02(TEMP)^2
AREA 35
(NORTHEASTERN UNITED STATES COAST)

Figure 10.

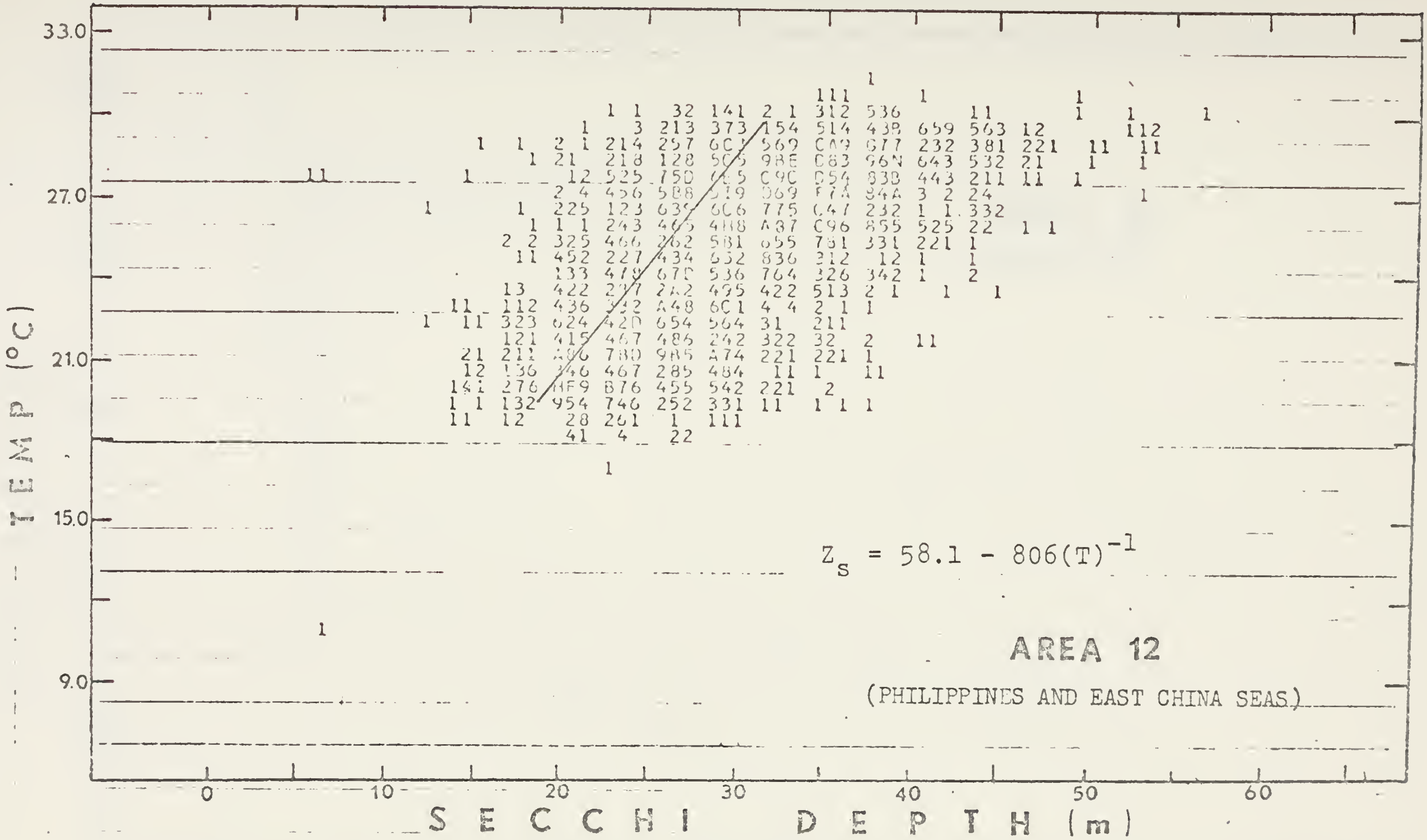

33.0
27.0
21.0
15.0
9.0
TEMP (°C)
0
10
20
30
40
50
60
SECCHI DEPTH (m)
$Z_s = 58.1 - 806(T)^{-1}$
AREA 12
(PHILIPPINES AND EAST CHINA SEAS)

Figure 11.

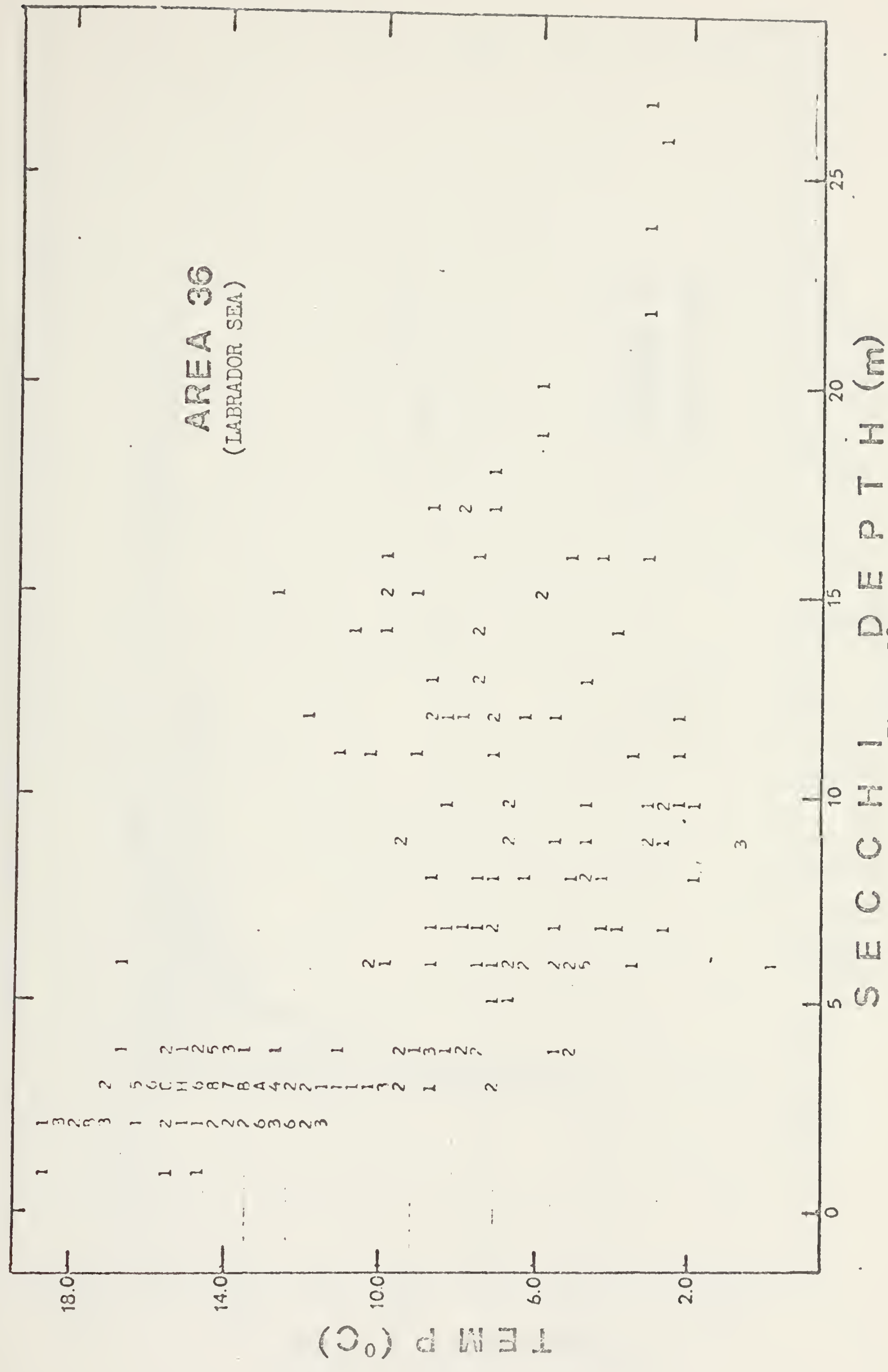

AREA 36
(LABRADOR SEA)
SECCHI DEPTH (m)
TEMP (°C)
0
5
10
15
20
25
18.0
14.0
10.0
6.0
2.0

Figure 12.

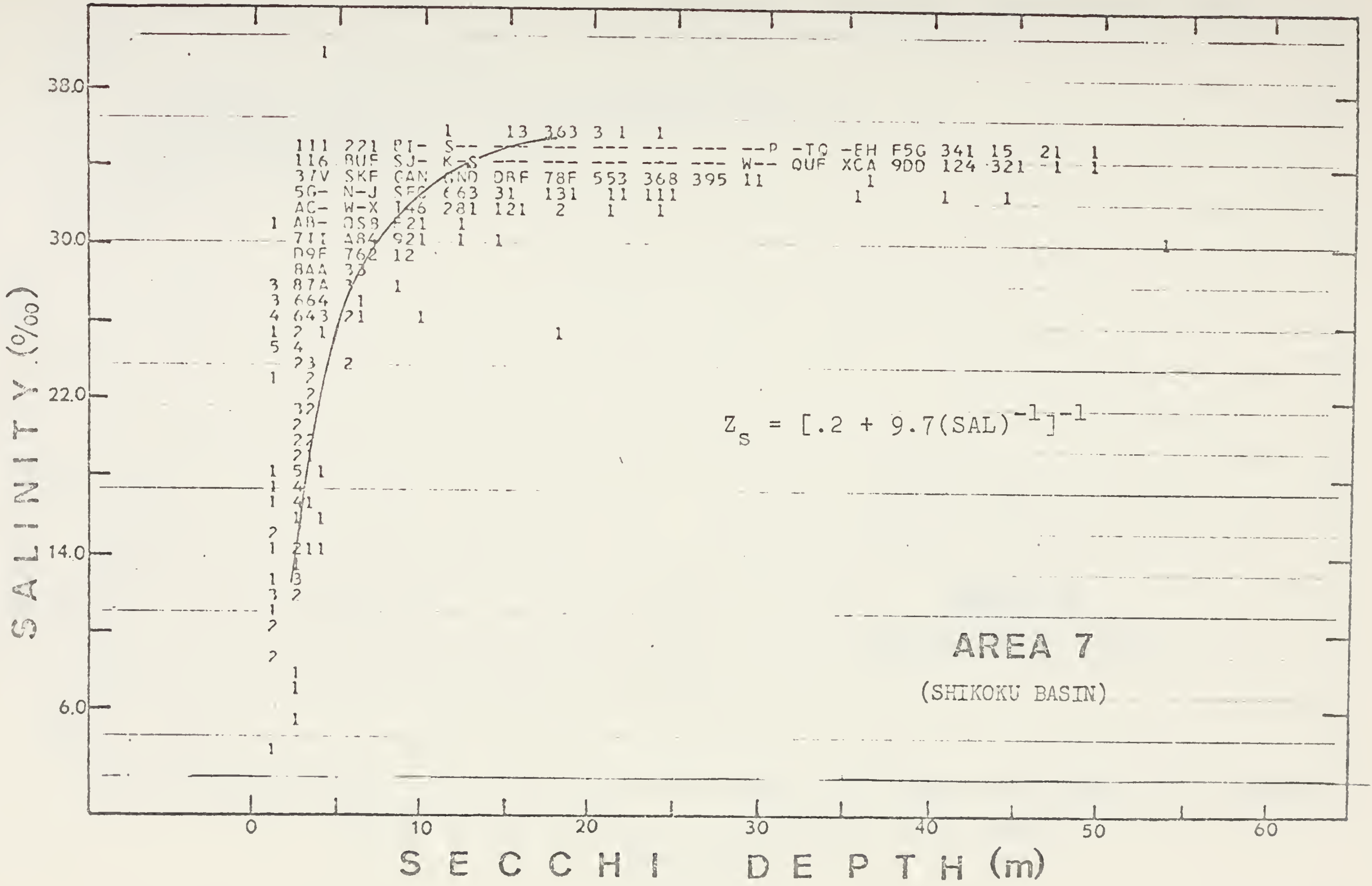

SALINITY (‰)
38.0
30.0
22.0
14.0
6.0
0
10
20
30
40
50
60
SECCHI DEPTH (m)
$Z_s = [.2 + 9.7(SAL)^{-1}]^{-1}$
AREA 7
(SHIKOKU BASIN)

Figure 13.

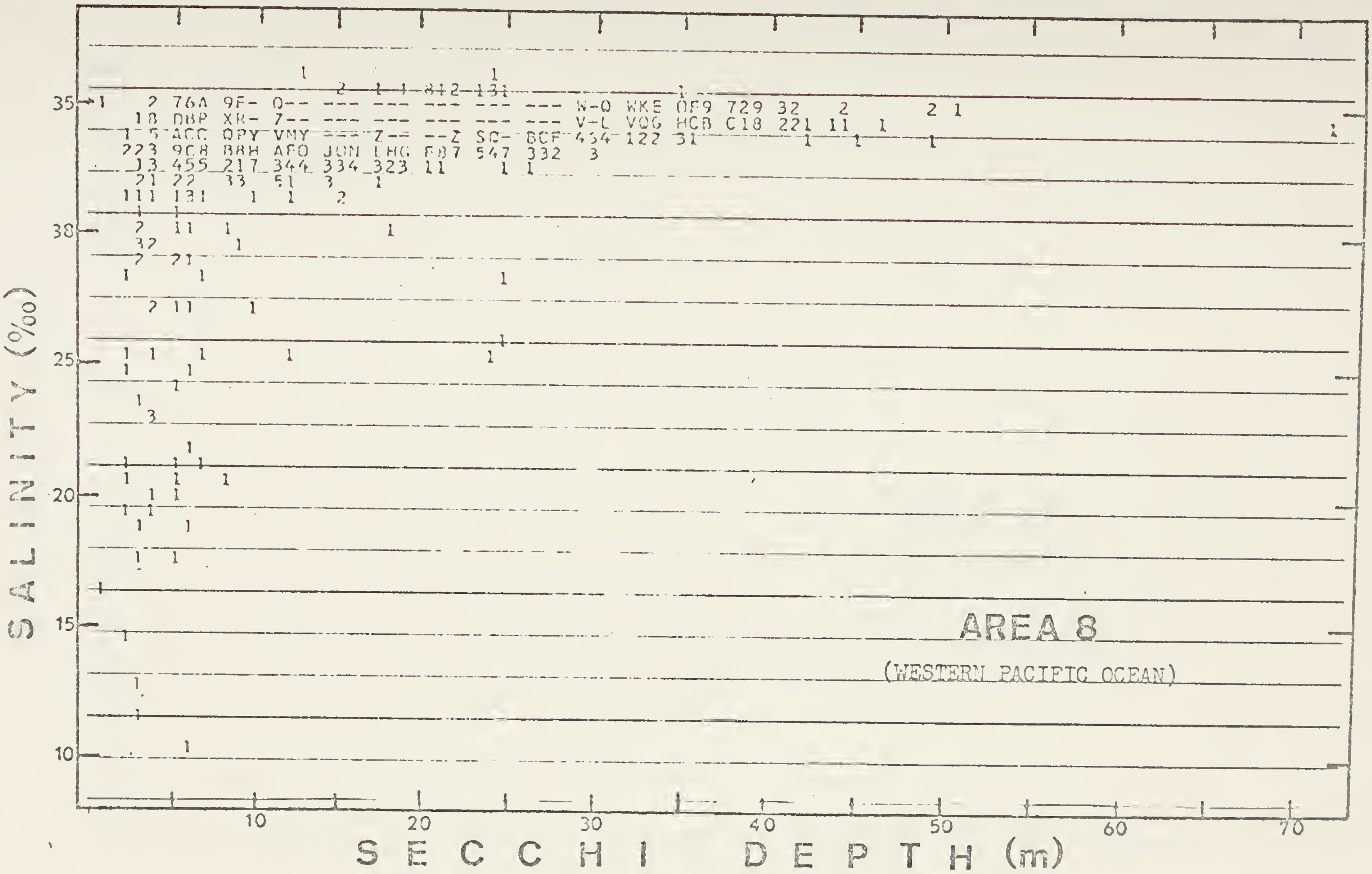

SALINITY (‰)
35
30
25
20
15
10
SECCHI DEPTH (m)
10
20
30
40
50
60
70
AREA 8
(WESTERN PACIFIC OCEAN)

Figure 14.

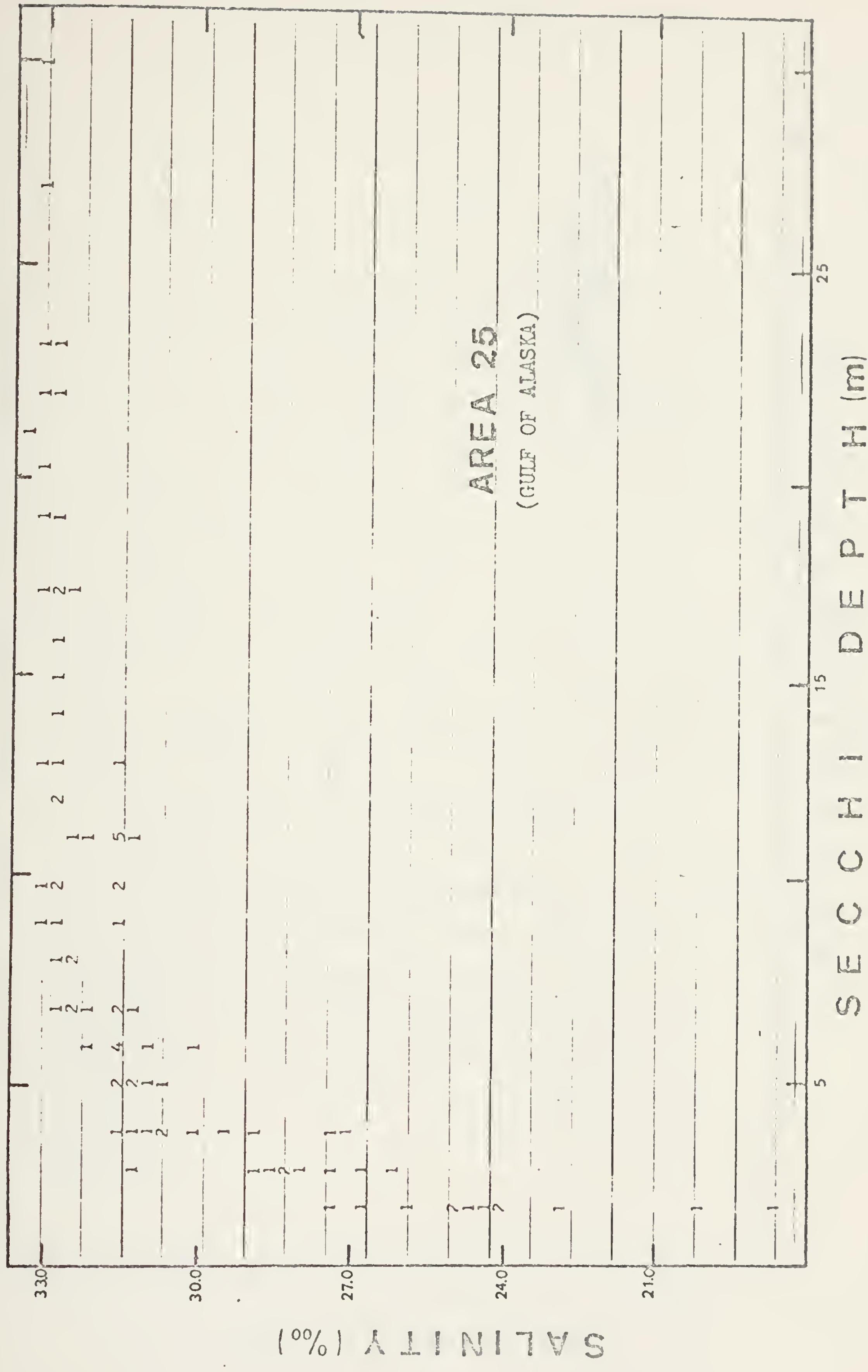

AREA 25
(GULF OF ALASKA)
SECCHI DEPTH (m)
5
15
25
SALINITY (‰)
33.0
30.0
27.0
24.0
21.0

Figure 15.

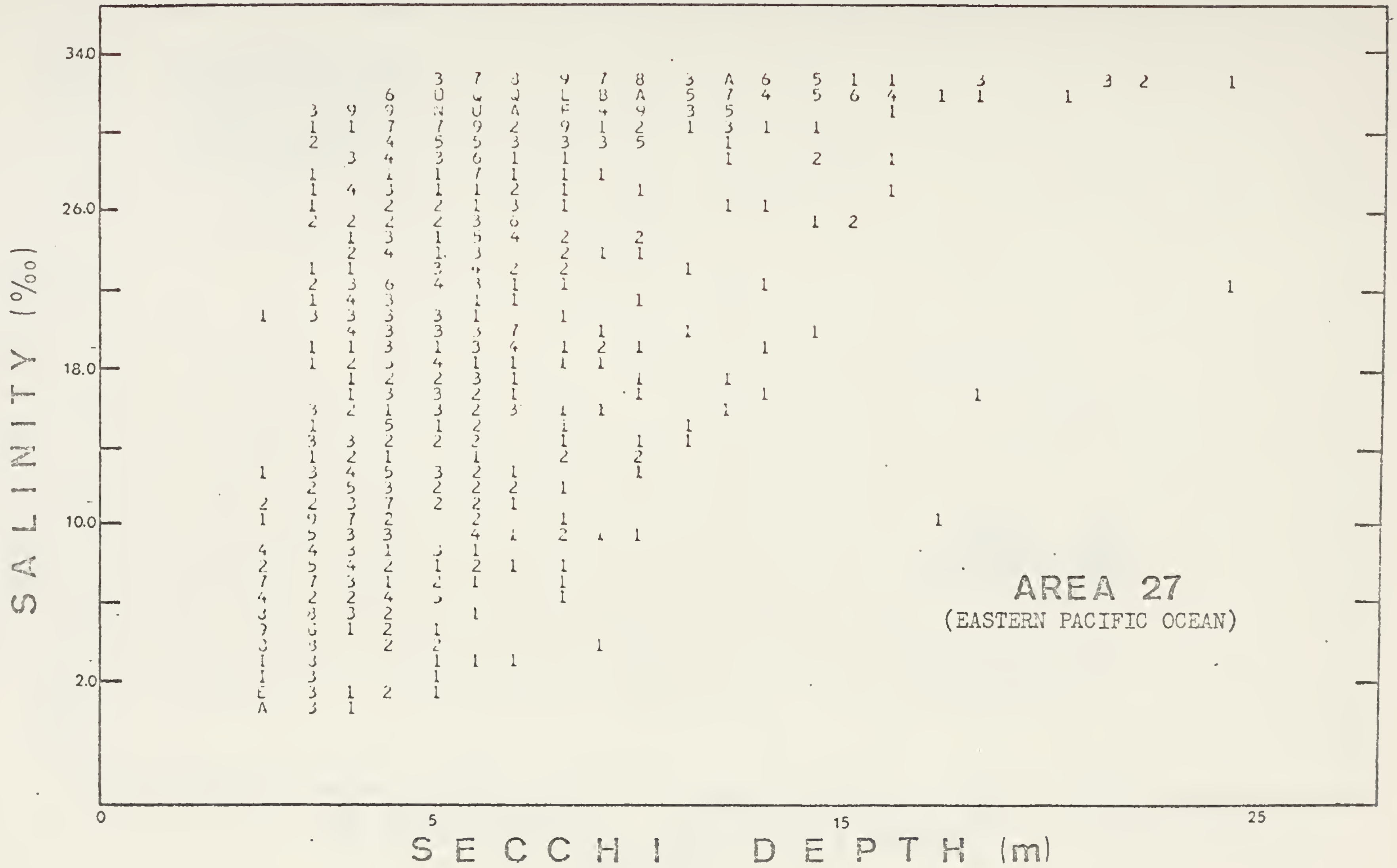

AREA 27
(EASTERN PACIFIC OCEAN)
SALINITY (°/oo)
34.0
26.0
18.0
10.0
2.0
SECCHI DEPTH (m)
0
5
15
25

Figure 16.

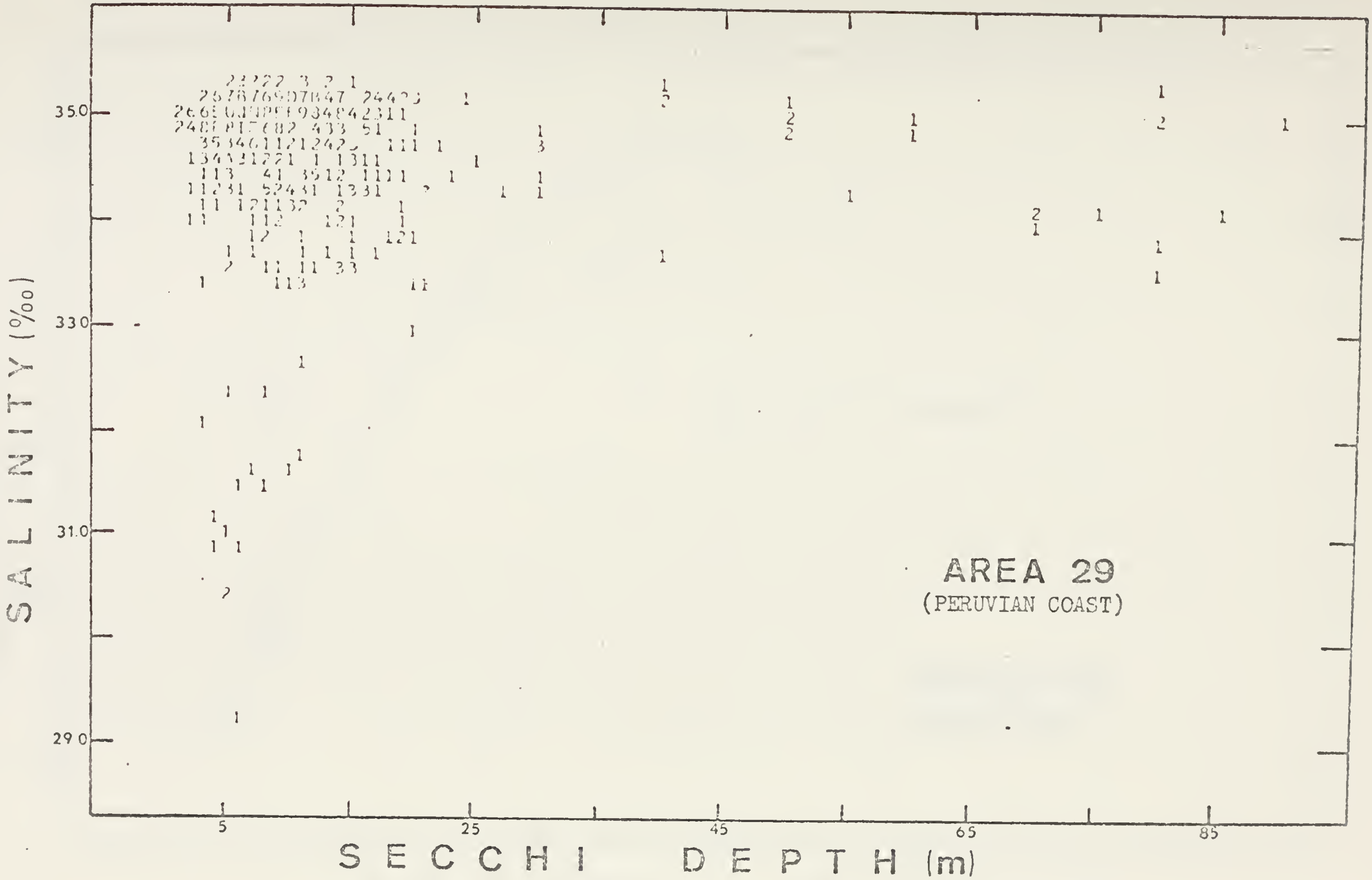

AREA 29
(PERUVIAN COAST)
SALINITY (‰)
35.0
33.0
31.0
29.0
SECCHI DEPTH (m)
5
25
45
65
85

Figure 17.

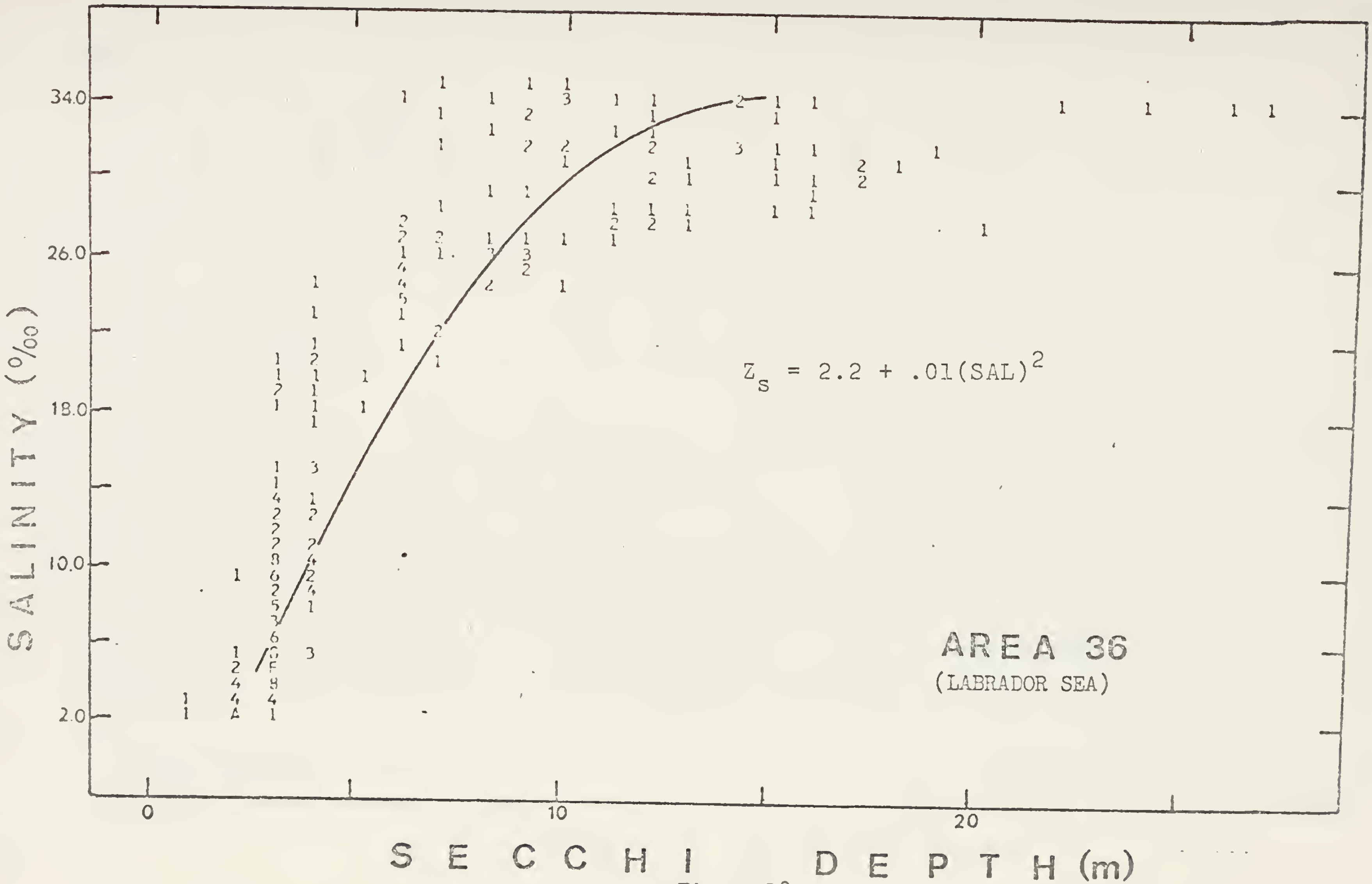

34.0
26.0
18.0
10.0
2.0
SALINITY (‰)
0
10
20
SECCHI DEPTH (m)
$Z_S = 2.2 + .01(SAL)^2$
AREA 36
(LABRADOR SEA)

Figure 18.

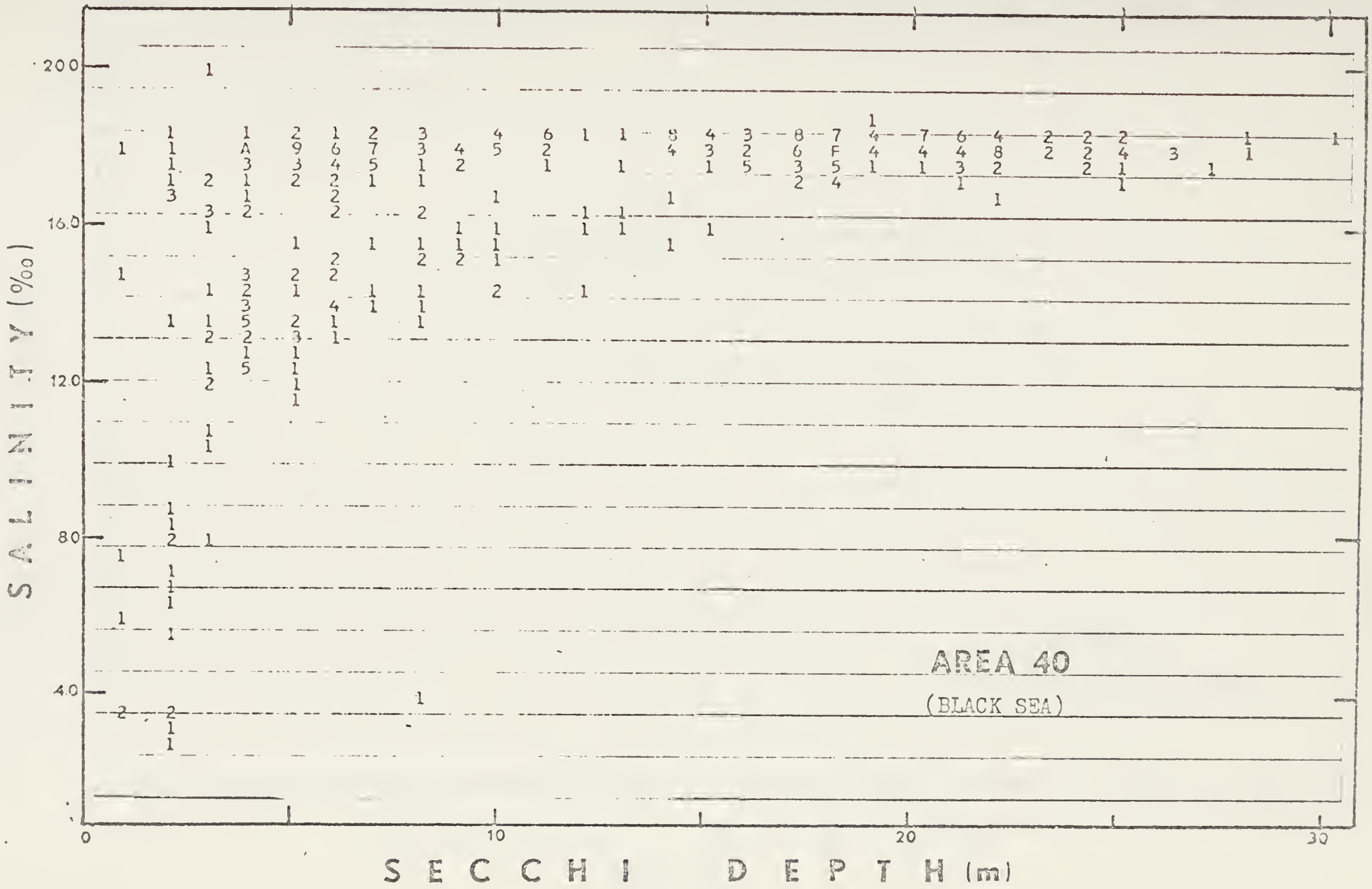

SALINITY (‰)
20.0
16.0
12.0
8.0
4.0
0
10
20
30
SECCHI DEPTH (m)
AREA 40
(BLACK SEA)

Figure 19.

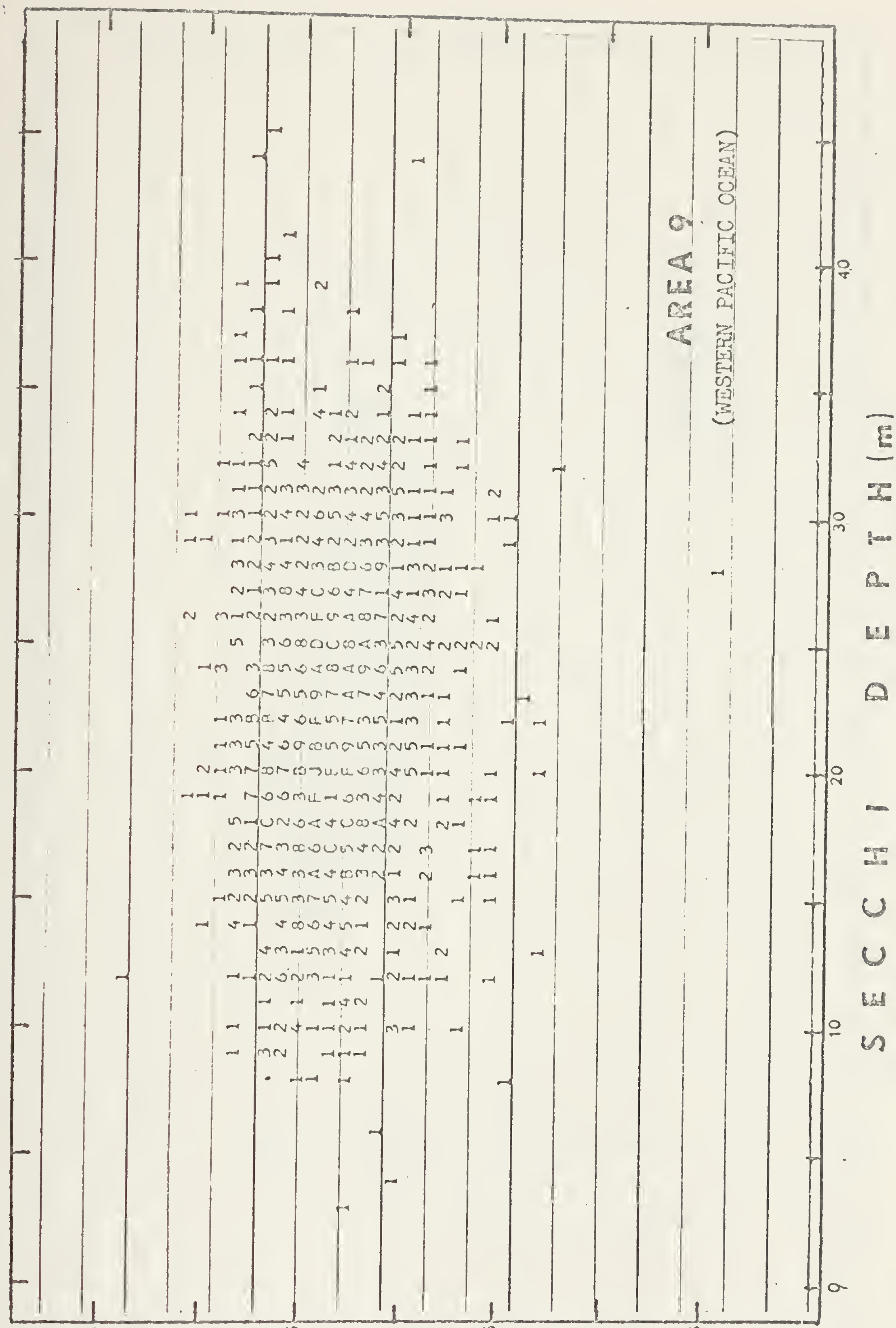

AREA 9
(WESTERN PACIFIC OCEAN)
SECCHI DEPTH (m)
SALINITY (‰)
9
10
20
30
40
35.5
34.5
33.5
32.5

Figure 20.

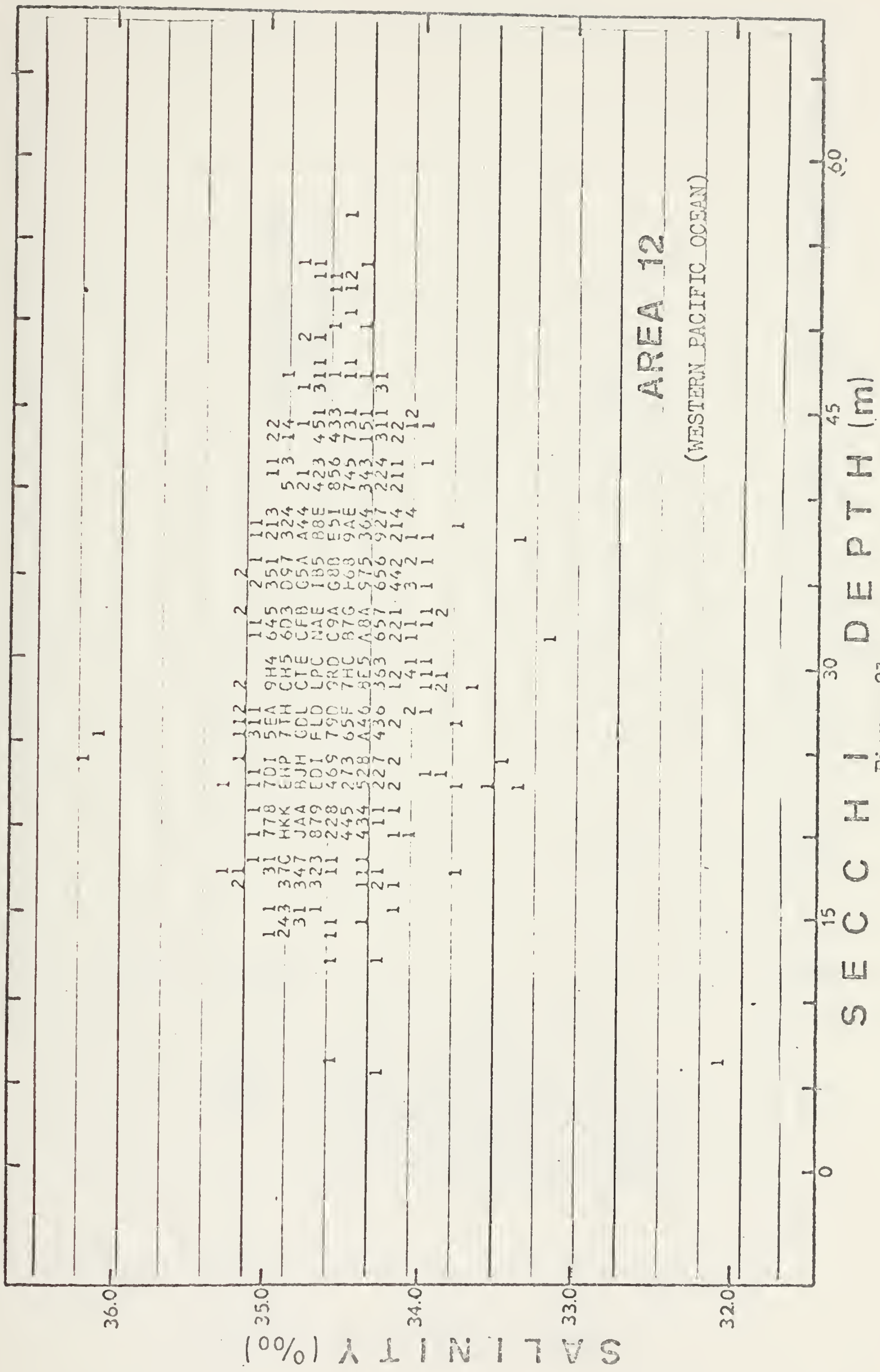

AREA 12
(WESTERN PACIFIC OCEAN)
S E C C H I   D E P T H (m)
0
15
30
45
60
S A L I N I T Y (0/00)
36.0
35.0
34.0
33.0
32.0

Figure 21.

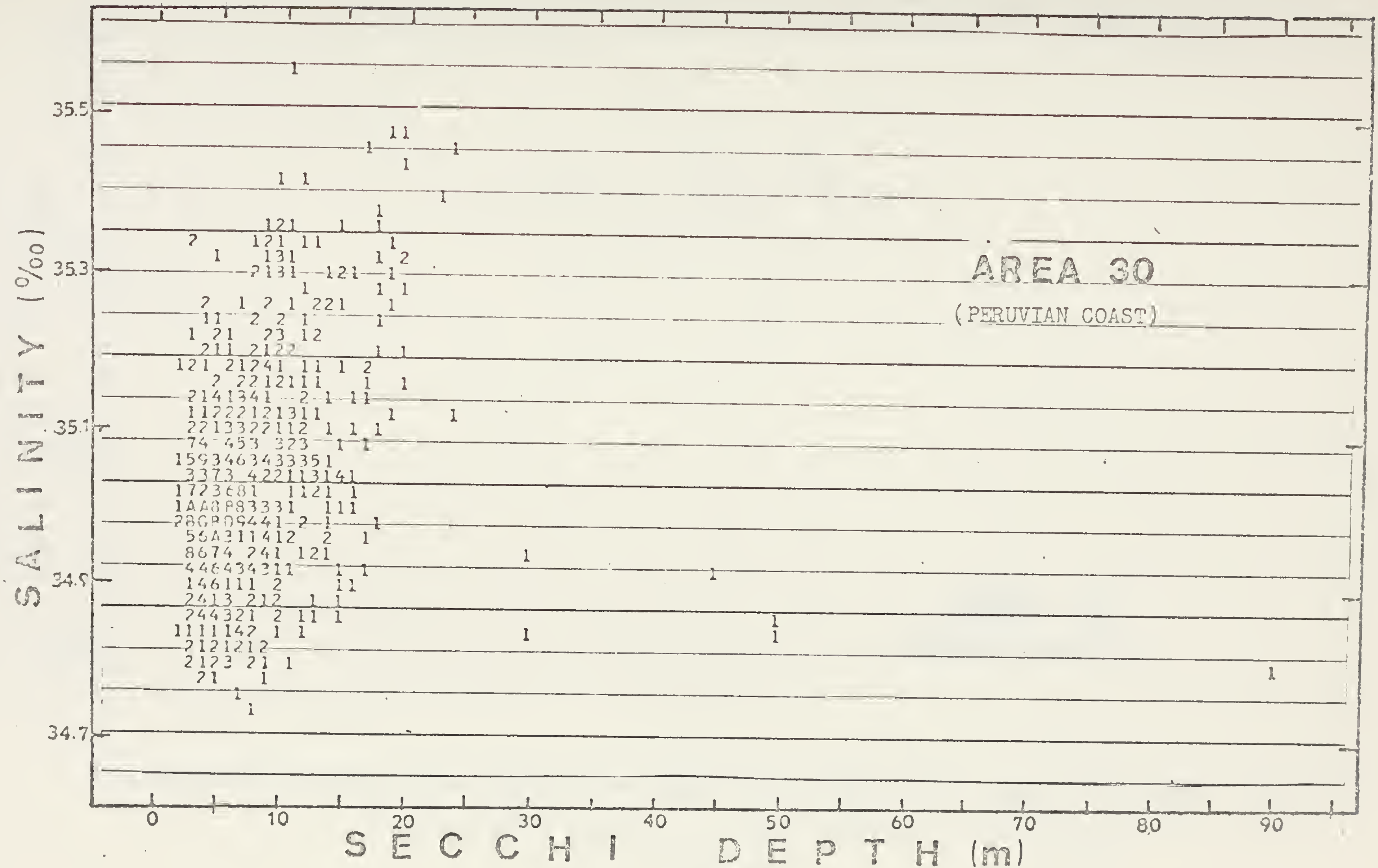

AREA 30
(PERUVIAN COAST)
SALINITY (0/00)
35.5
35.3
35.1
34.9
34.7
SECCHI DEPTH (m)
0
10
20
30
40
50
60
70
80
90

Figure 22.

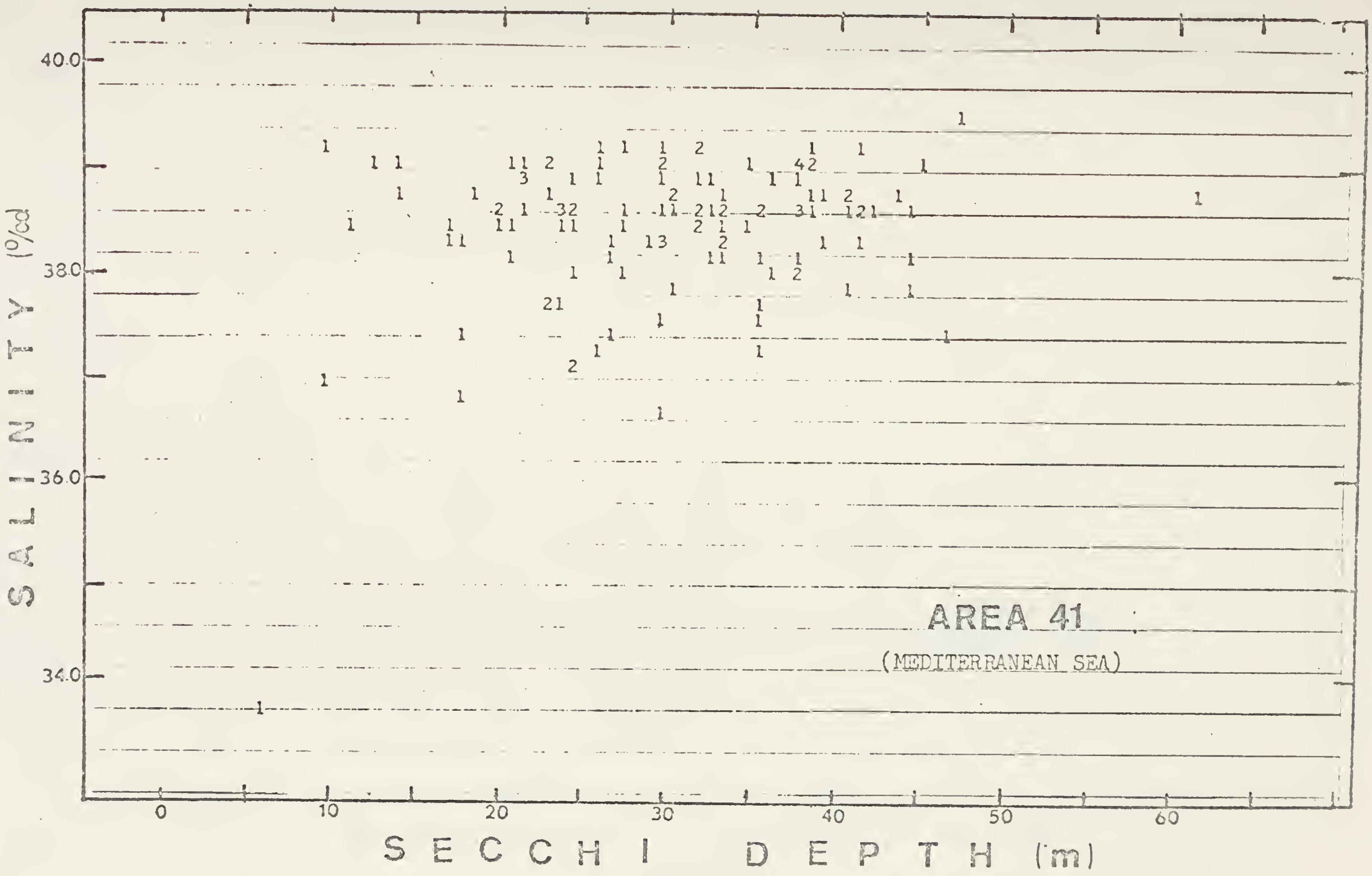

SALINITY (°/oo)
40.0
38.0
36.0
34.0
0
10
20
30
40
50
60
SECCHI DEPTH (m)
AREA 41
(MEDITERRANEAN SEA)

Figure 23.

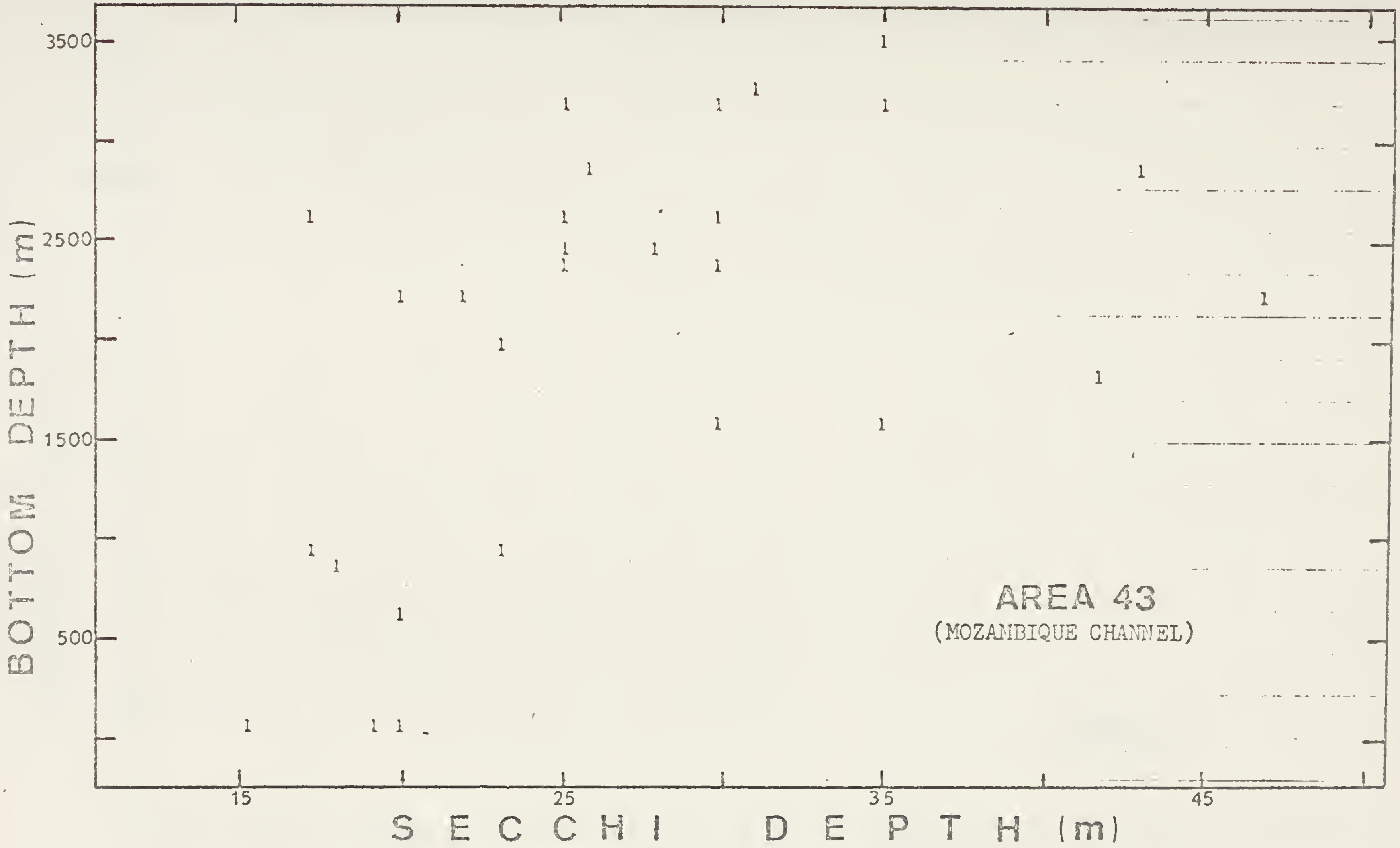

AREA 43
(MOZAMBIQUE CHANNEL)
BOTTOM DEPTH (m)
3500
2500
1500
500
SECCHI DEPTH (m)
15
25
35
45

Figure 24.

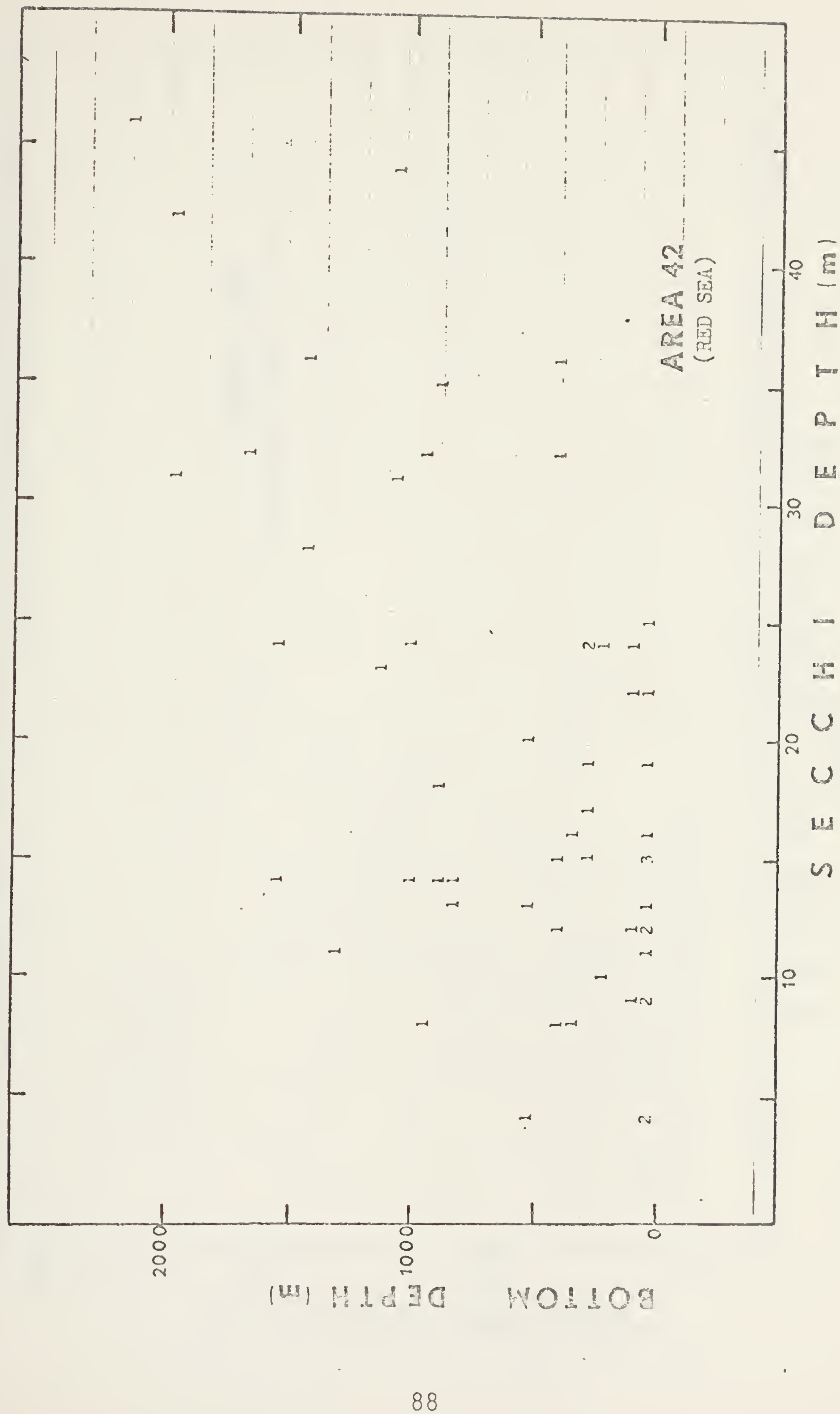

AREA 42
(RED SEA)
S E C C H I   D E P T H (m)
10
20
30
40
BOTTOM DEPTH (m)
0
1000
2000

Figure 25.

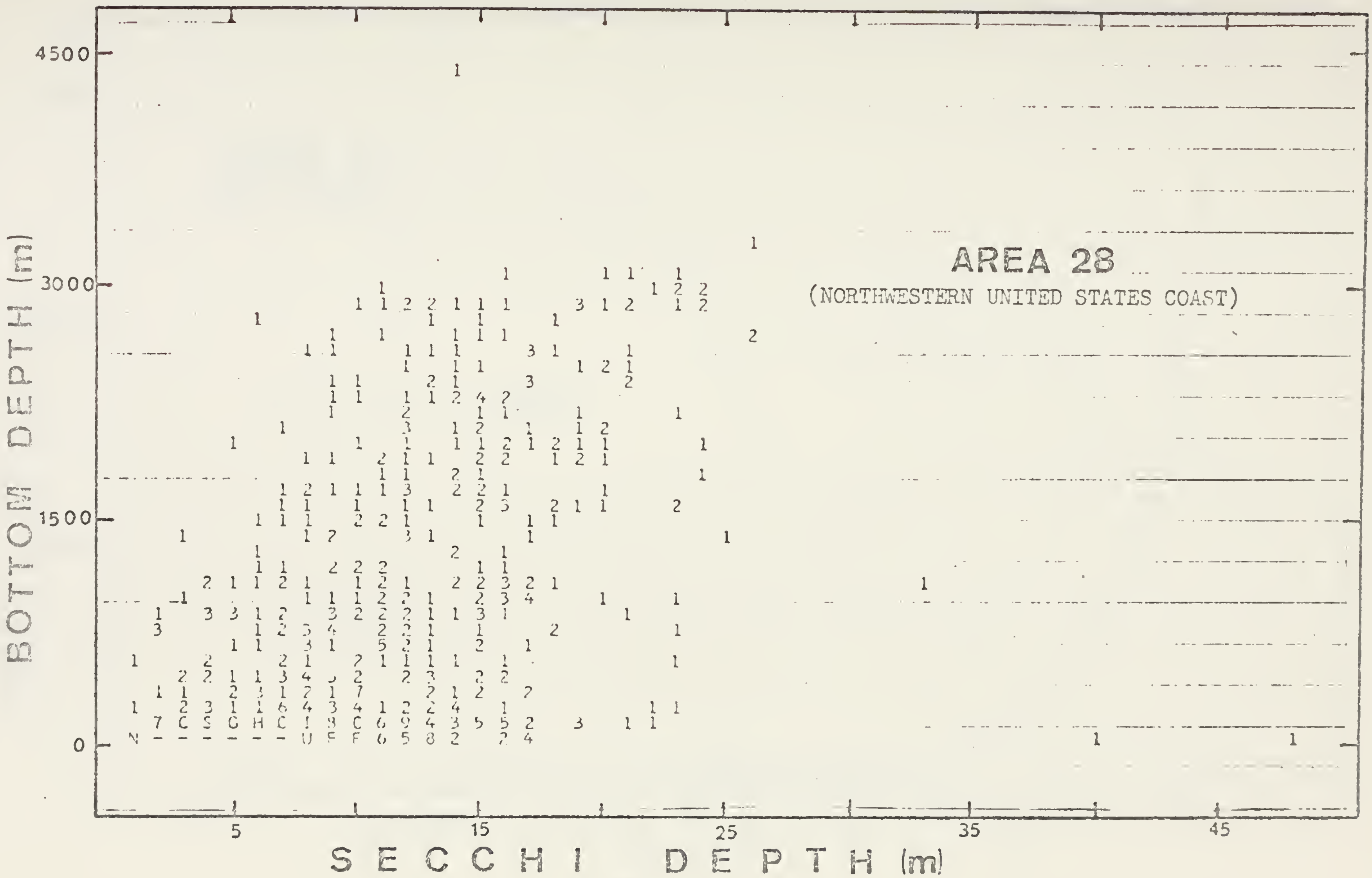

AREA 28
(NORTHWESTERN UNITED STATES COAST)
BOTTOM DEPTH (m)
4500
3000
1500
0
SECCHI DEPTH (m)
5
15
25
35
45

Figure 26.

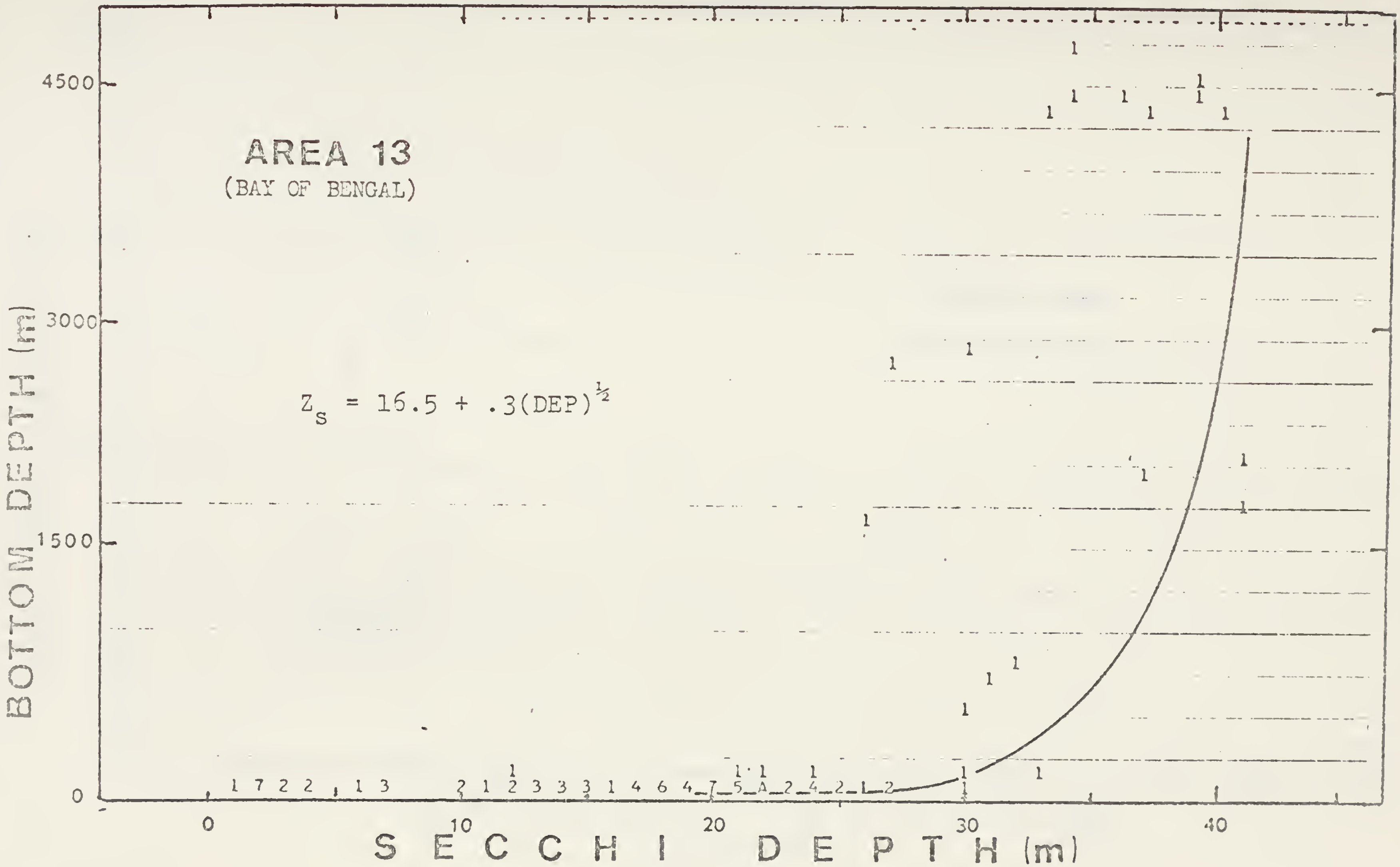

AREA 13
(BAY OF BENGAL)
$Z_s = 16.5 + .3(DEP)^{1/2}$
BOTTOM DEPTH (m)
4500
3000
1500
0
SECCHI DEPTH (m)
0
10
20
30
40

Figure 27.

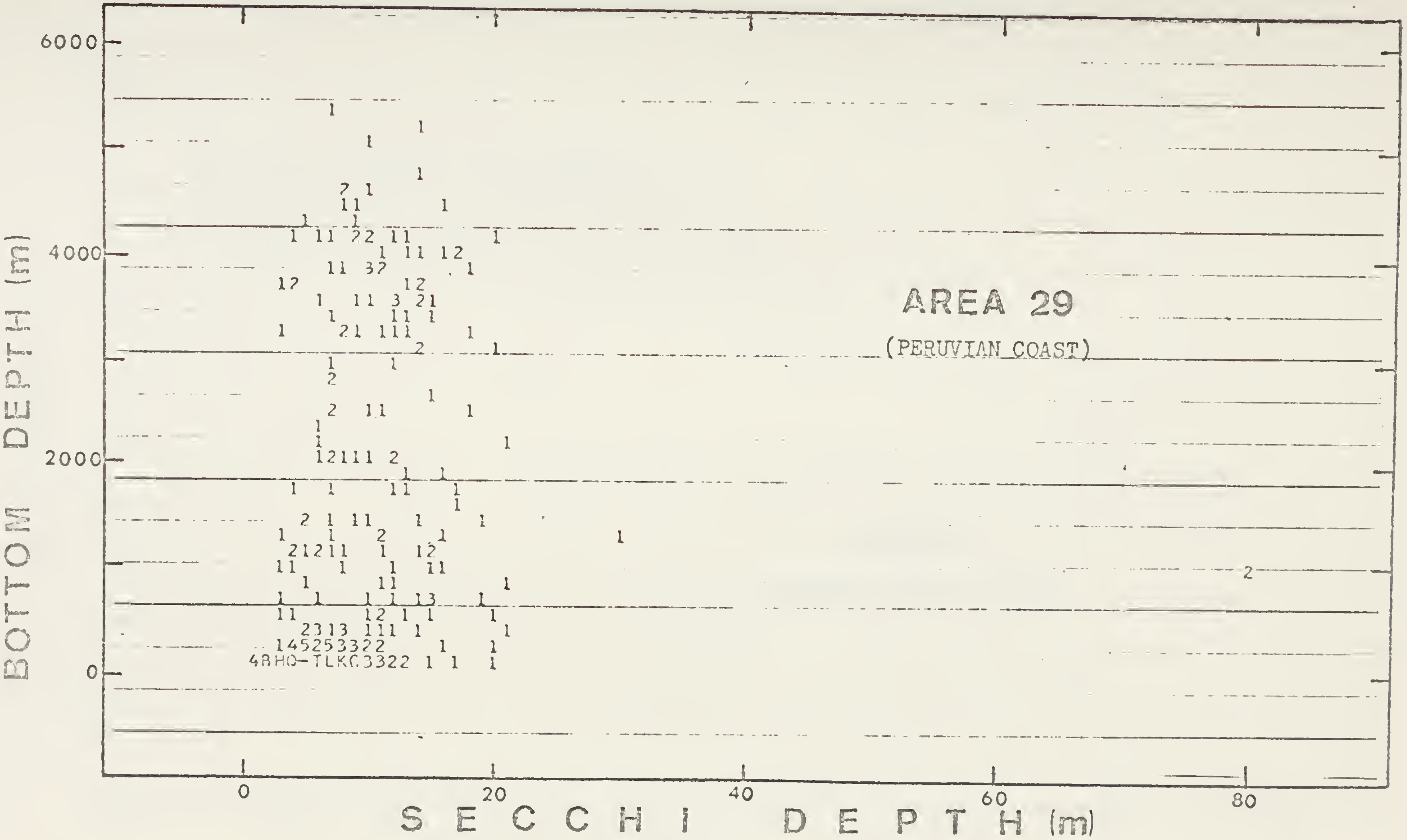

AREA 29
(PERUVIAN COAST)
BOTTOM DEPTH (m)
6000
4000
2000
0
SECCHI DEPTH (m)
0
20
40
60
80

Figure 28.

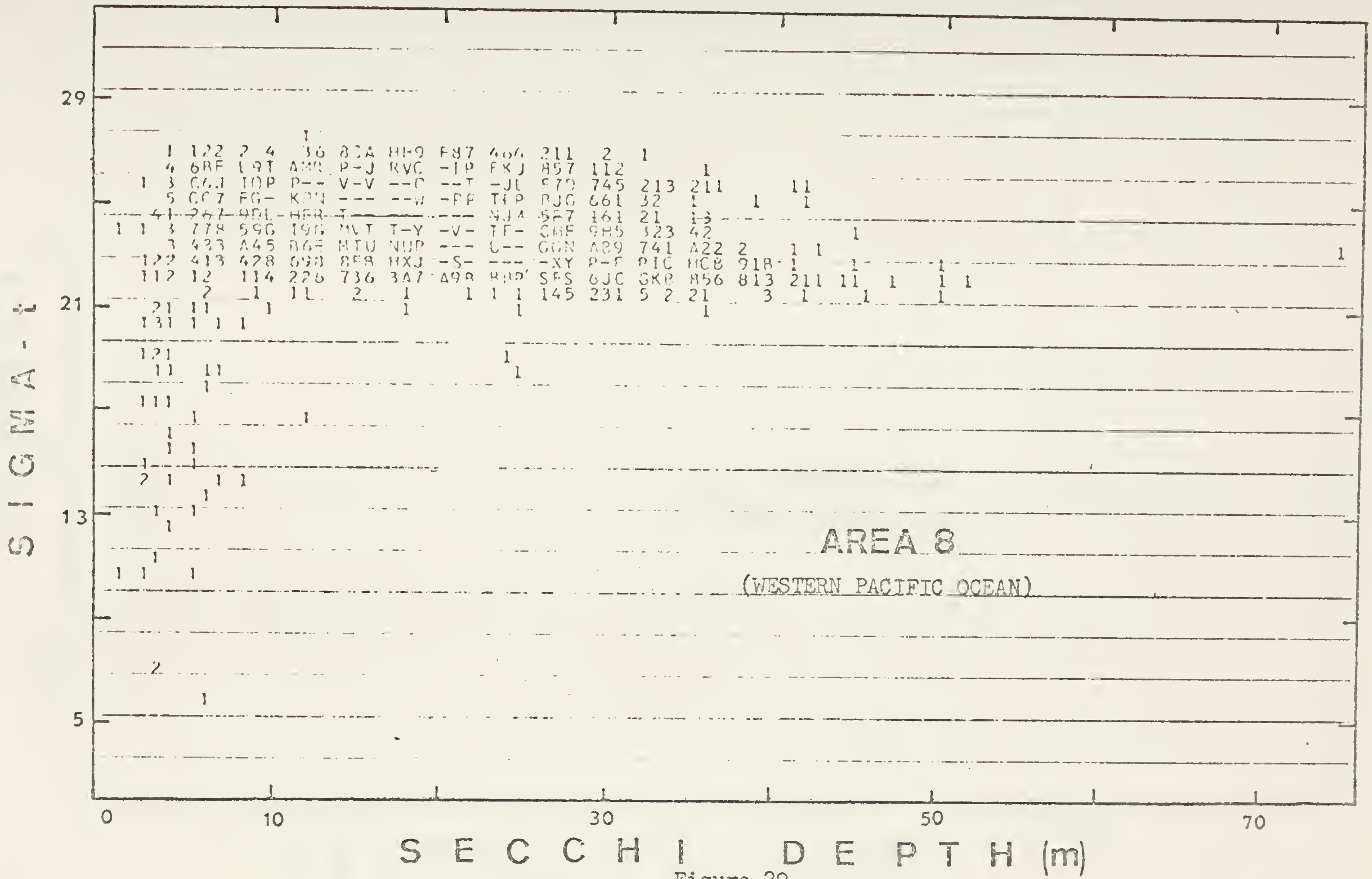

29
21
13
5
SIGMA - t
0
10
30
50
70
SECCHI DEPTH (m)
AREA 8
(WESTERN PACIFIC OCEAN)

Figure 29.

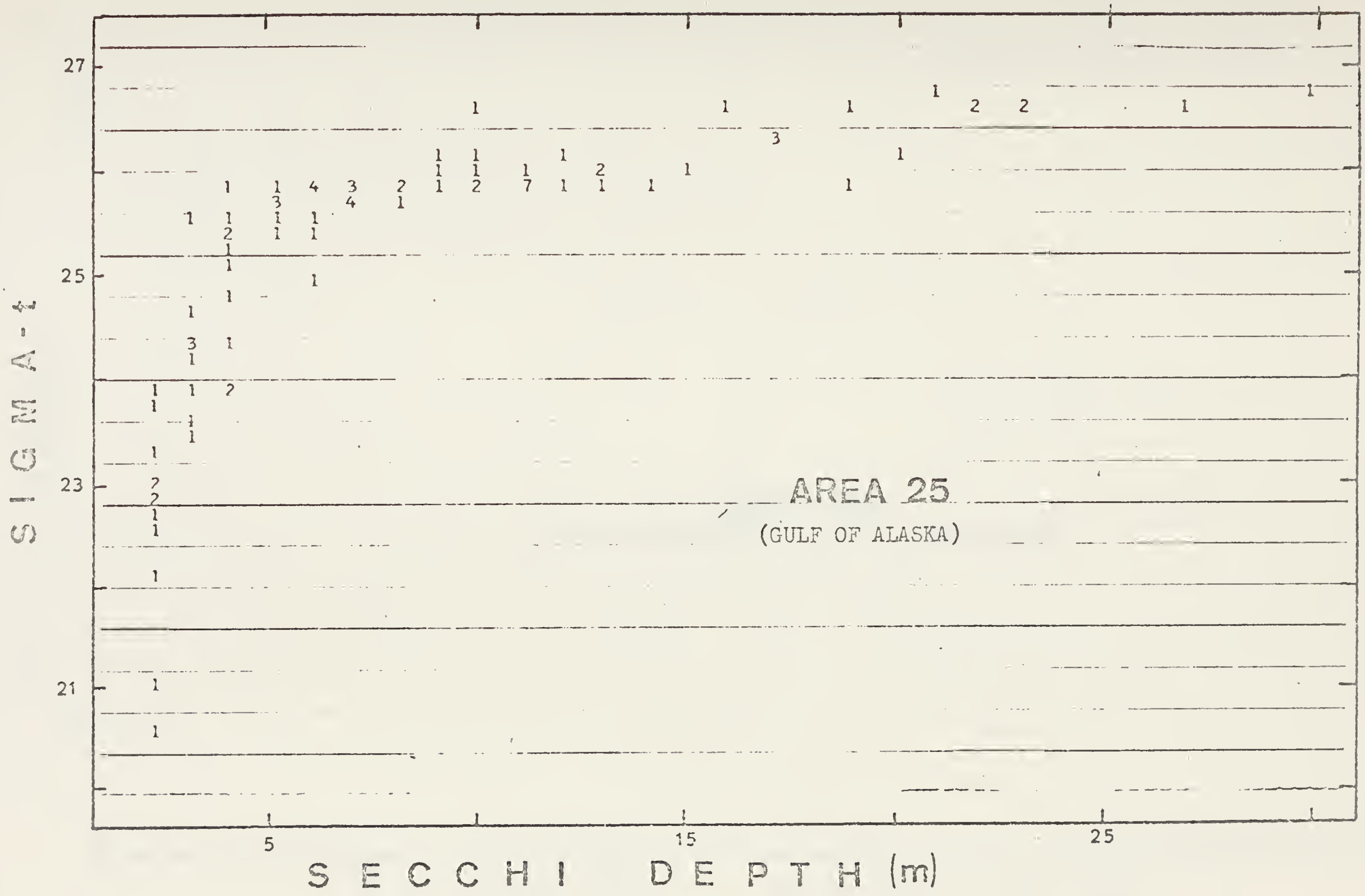


Figure 30.

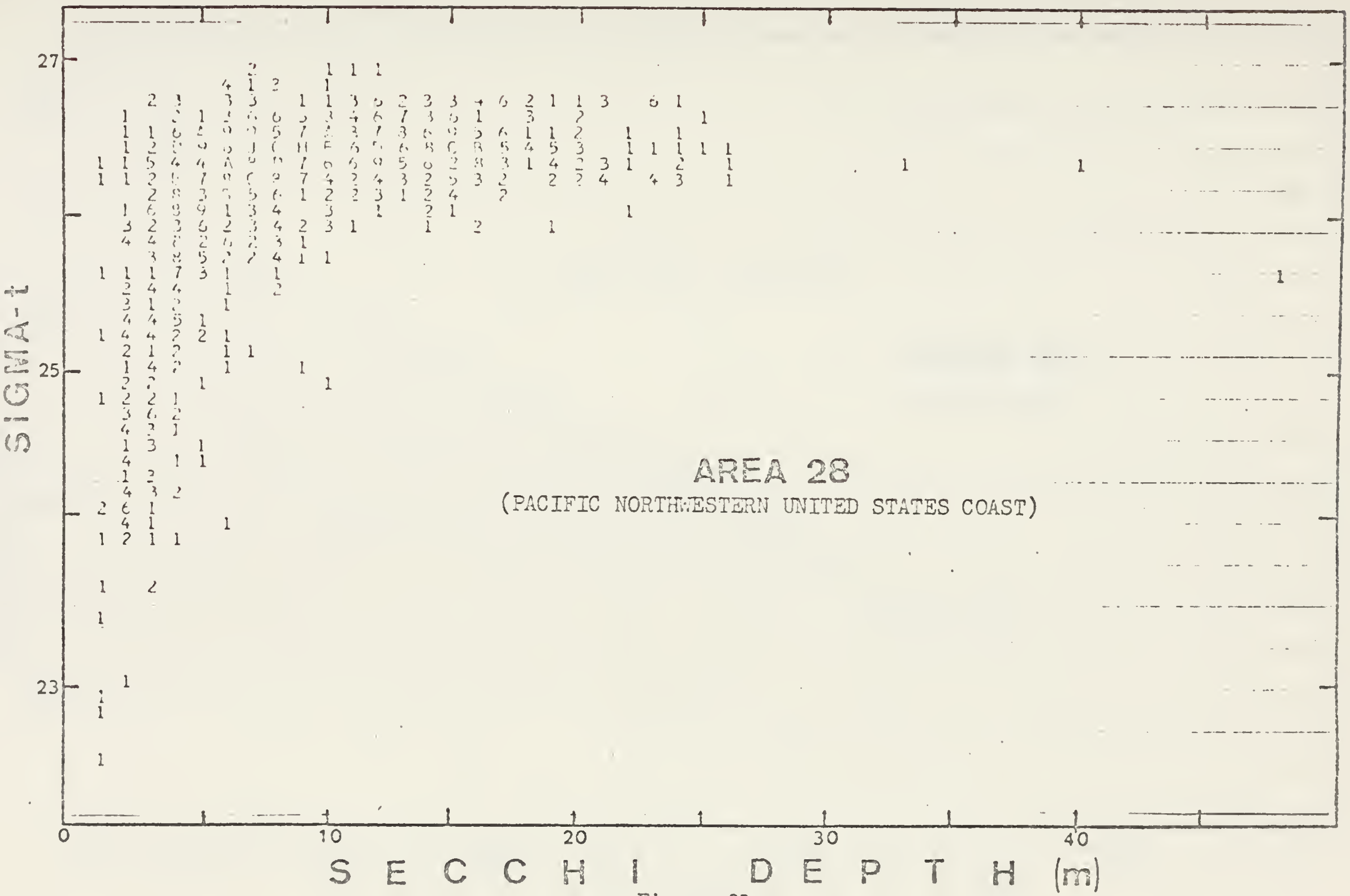

AREA 28
(PACIFIC NORTHWESTERN UNITED STATES COAST)
SIGMA-t
27
25
23
0
10
20
30
40
SECCHI DEPTH (m)

Figure 31.

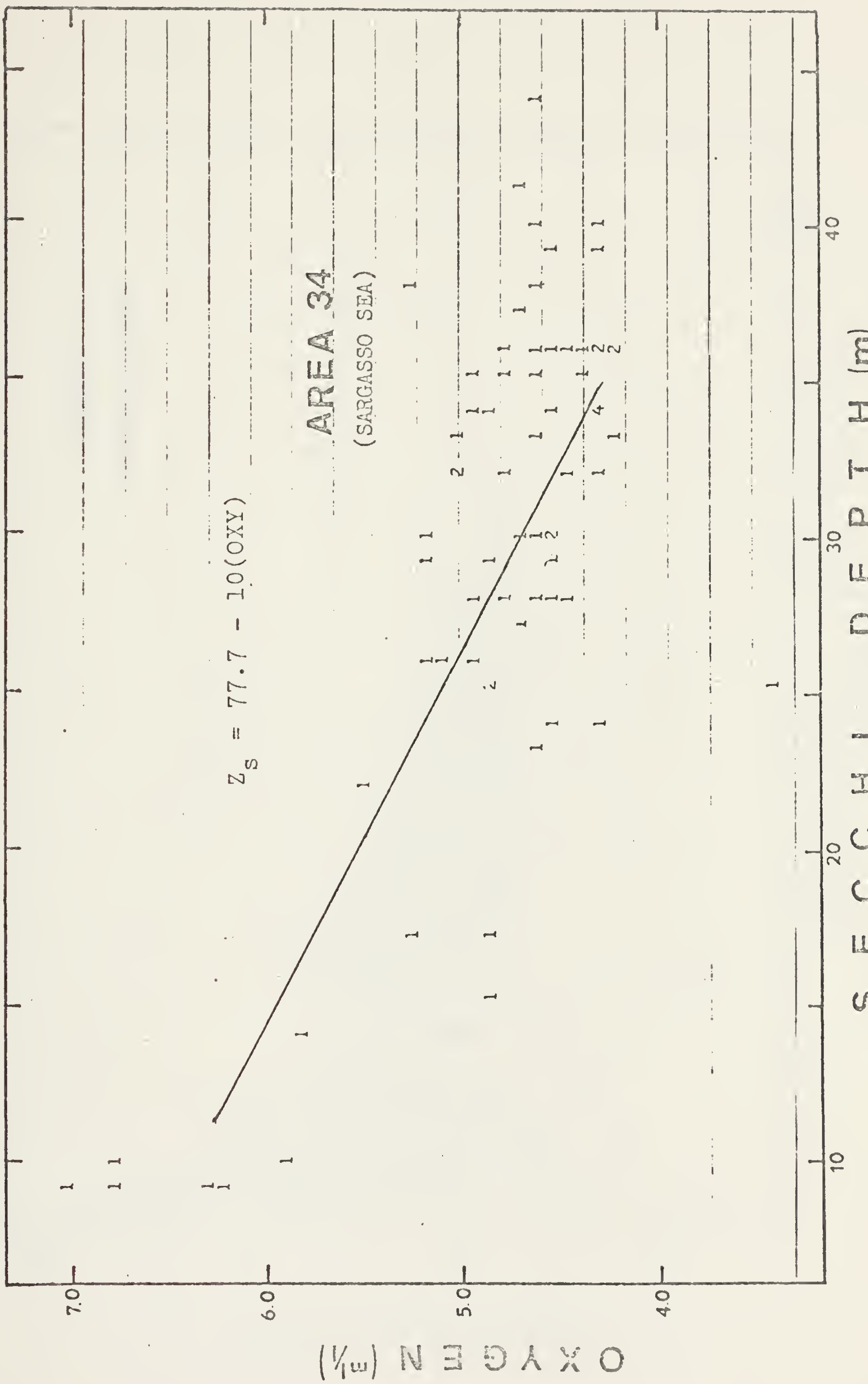

AREA 34
(SARGASSO SEA)
Z_S = 77.7 - 10(OXY)
7.0
6.0
5.0
4.0
OXYGEN (ml/l)
10
20
30
40
SECCHI DEPTH (m)

Figure 32.

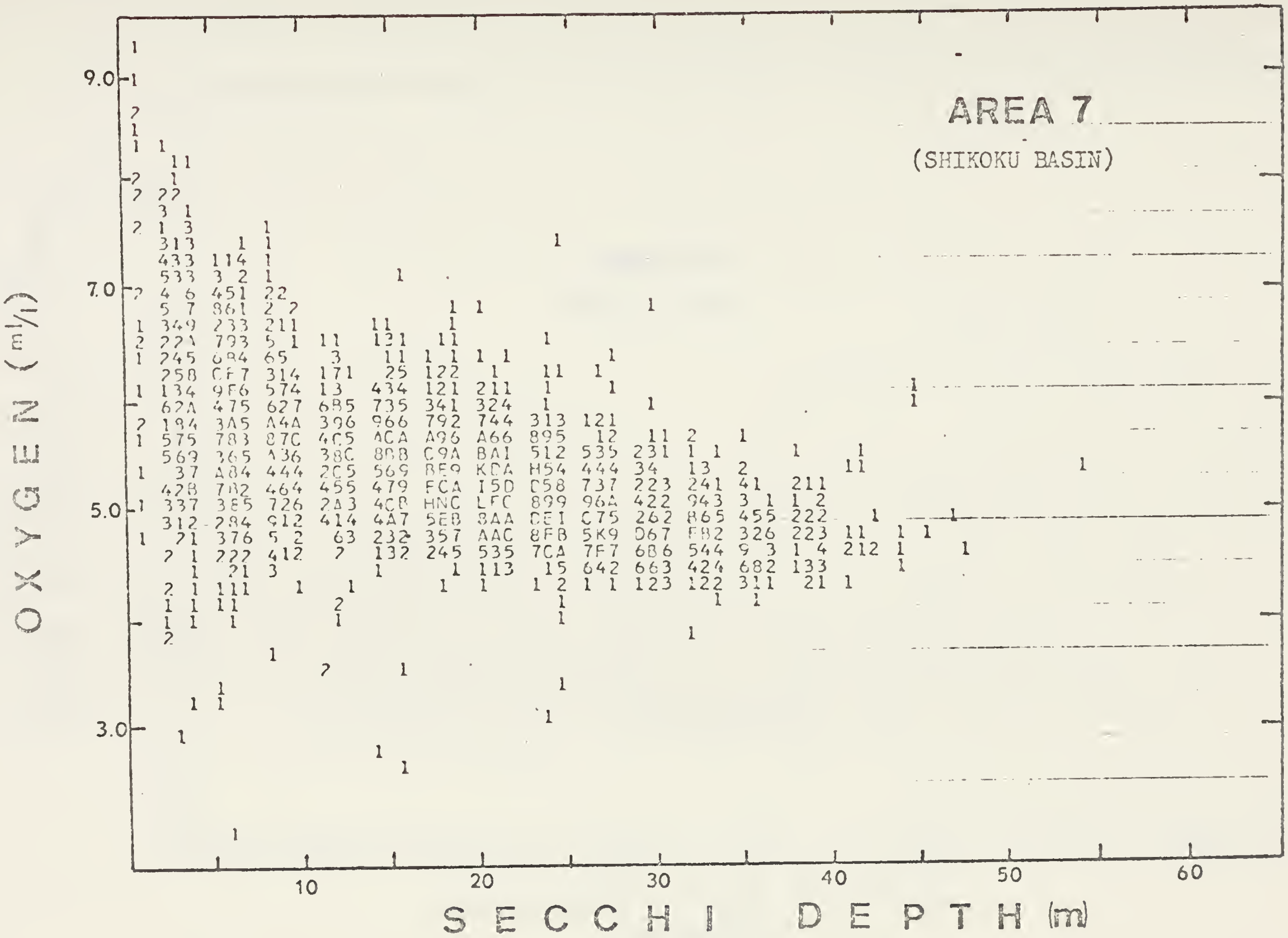

AREA 7
(SHIKOKU BASIN)
OXYGEN (ml/l)
9.0
7.0
5.0
3.0
SECCHI DEPTH (m)
10
20
30
40
50
60

Figure 33.

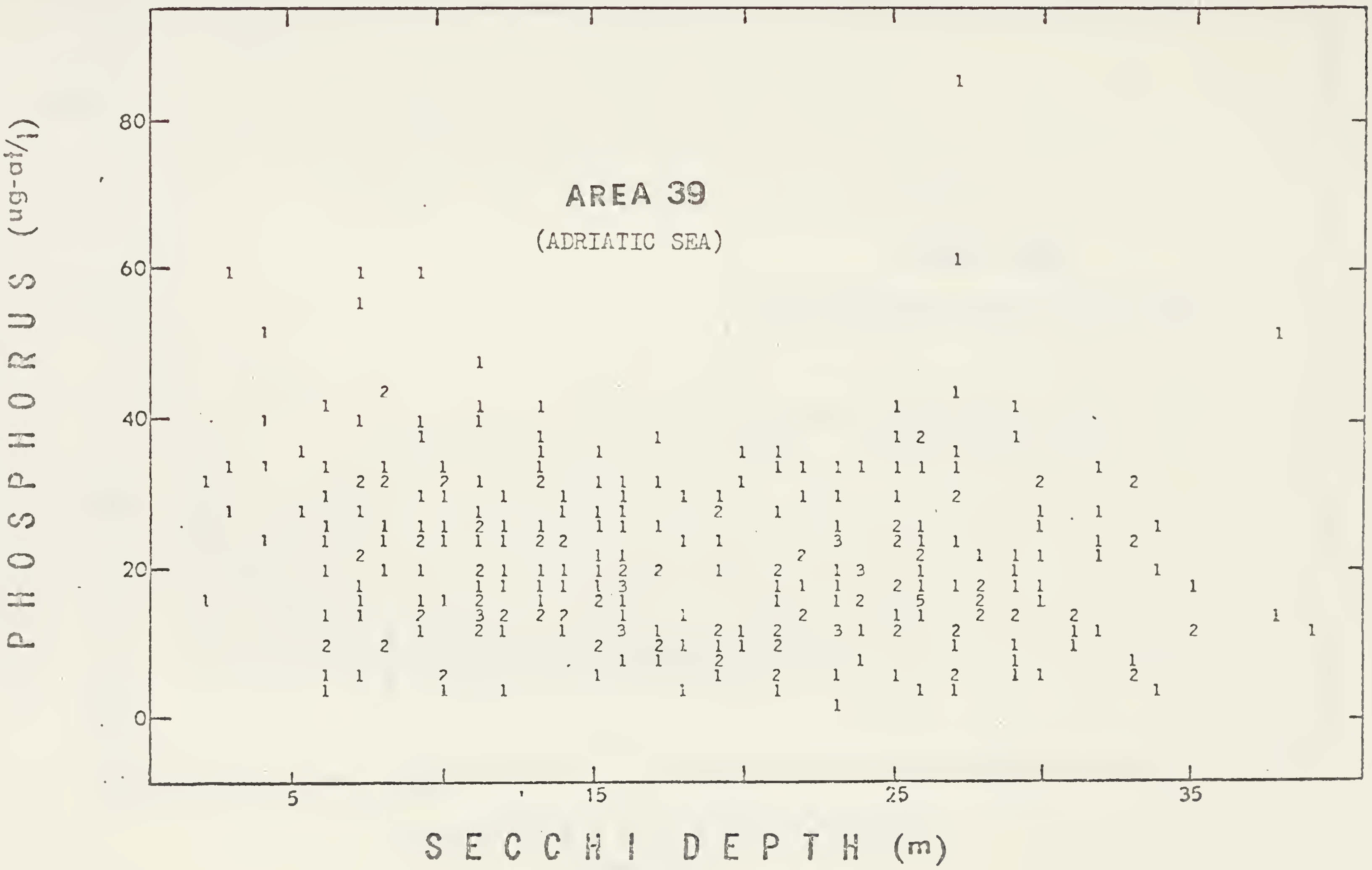

AREA 39
(ADRIATIC SEA)
PHOSPHORUS (ug-at/l)
0
20
40
60
80
5
15
25
35
SECCHI DEPTH (m)

Figure 34.

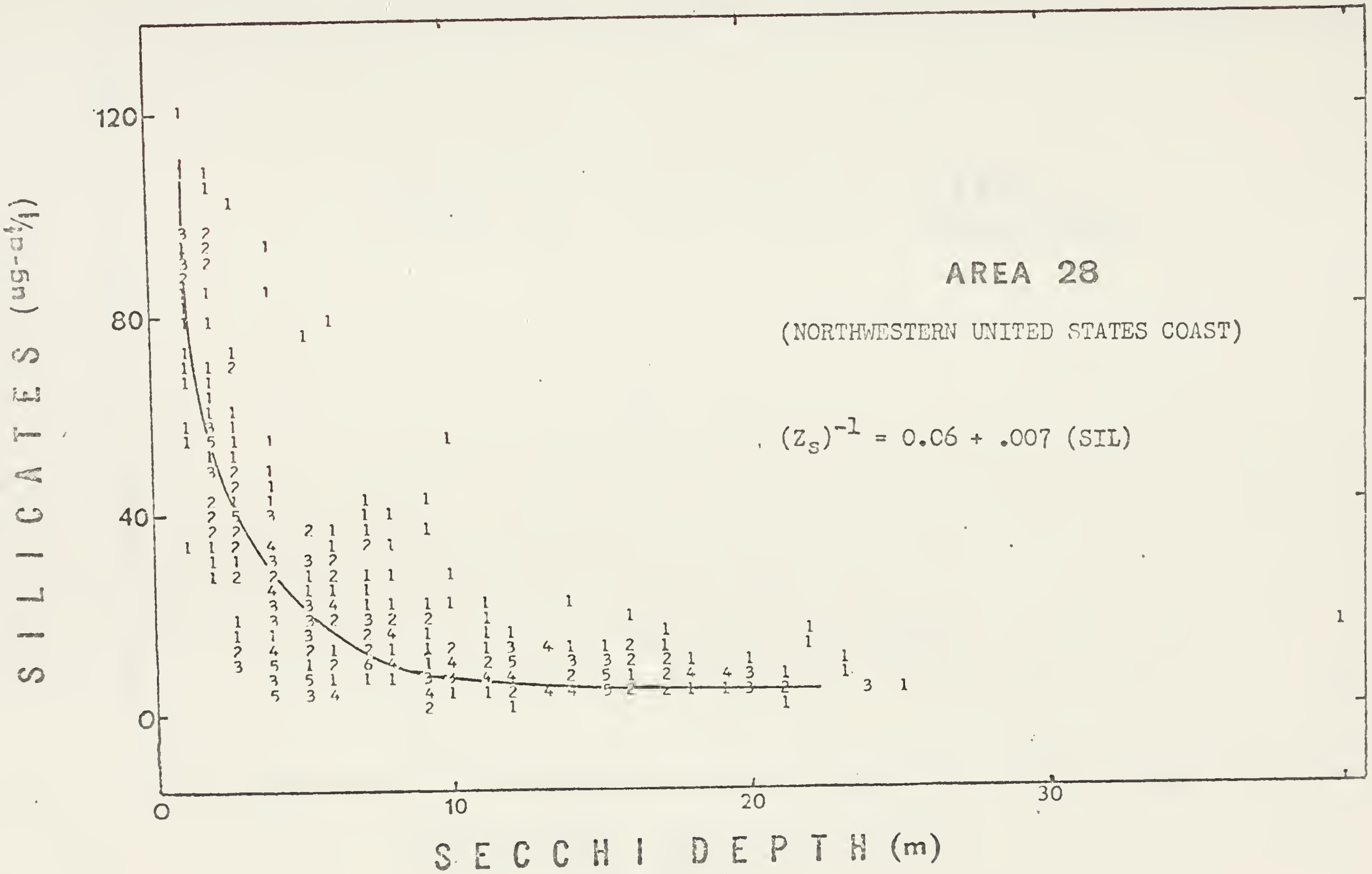

AREA 28
(NORTHWESTERN UNITED STATES COAST)
$(Z_s)^{-1} = 0.06 + .007\ (SIL)$
SILICATES (ug-at/l)
120
80
40
0
SECCHI DEPTH (m)
0
10
20
30

Figure 35.

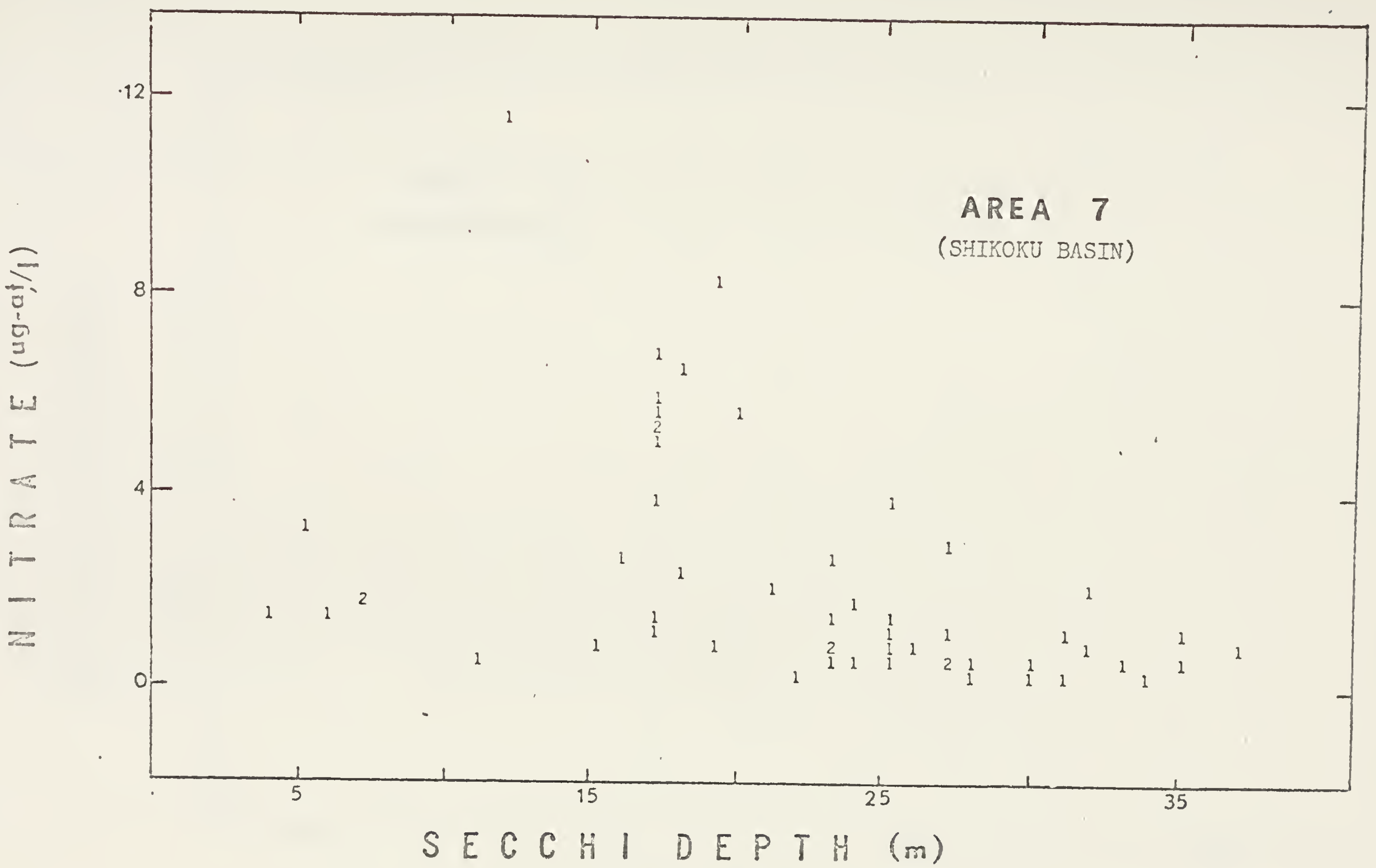

AREA 7
(SHIKOKU BASIN)
NITRATE (ug-at/l)
12
8
4
0
5
15
25
35
SECCHI DEPTH (m)

Figure 36.

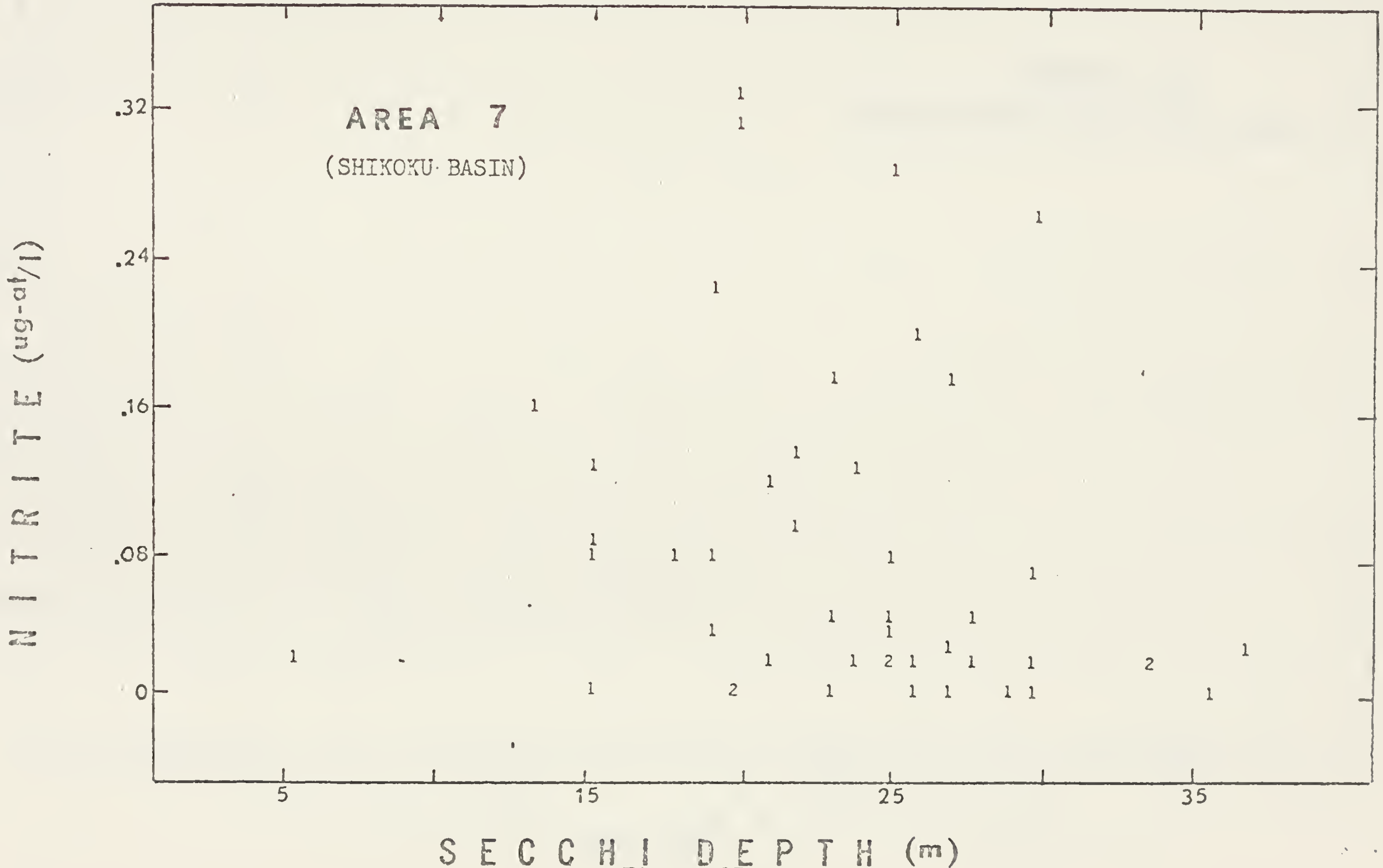

AREA 7
(SHIKOKU BASIN)
NITRITE (ug-at/l)
.32
.24
.16
.08
0
5
15
25
35
SECCHI DEPTH (m)

Figure 37.

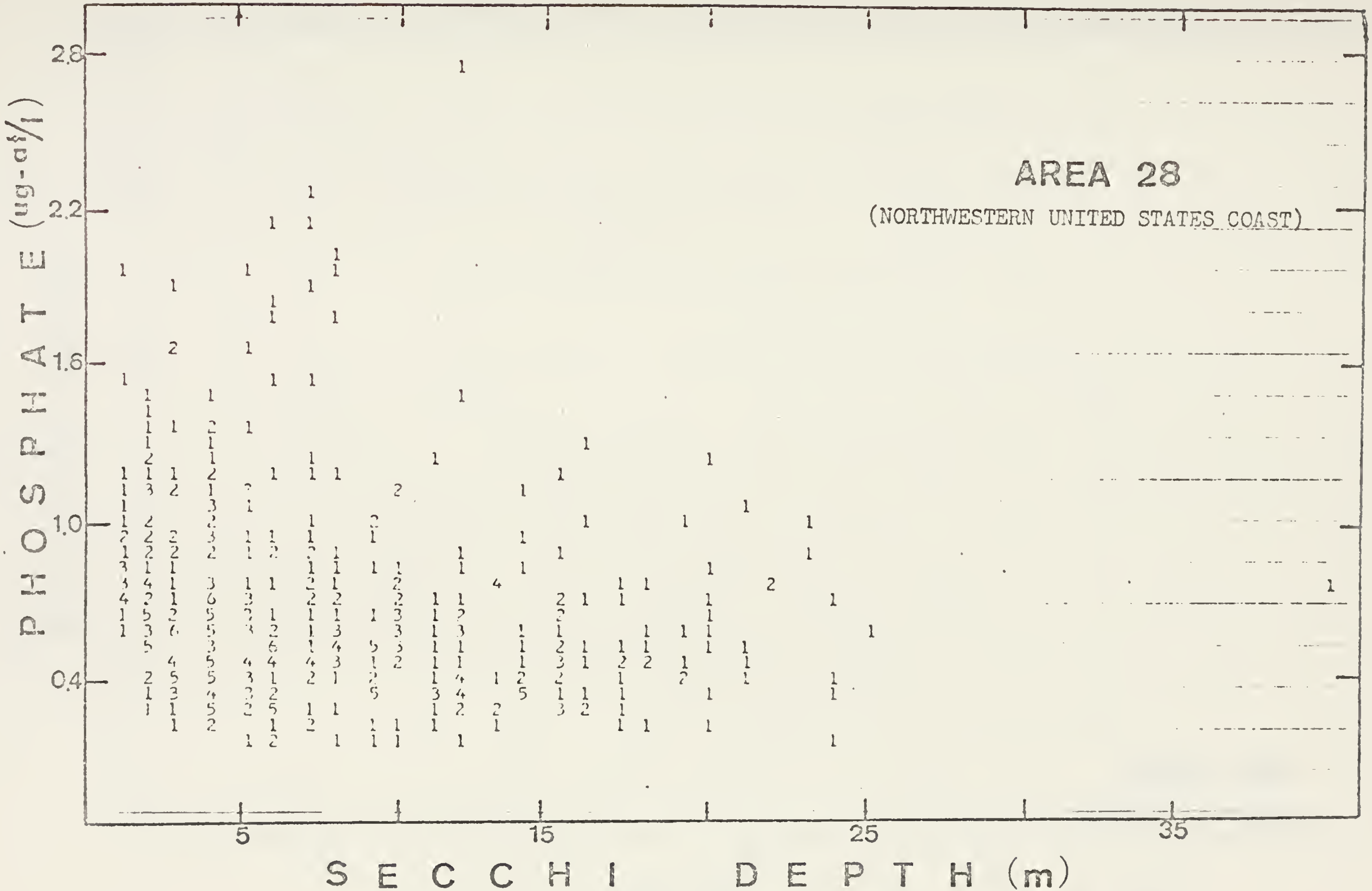

AREA 28
(NORTHWESTERN UNITED STATES COAST)
PHOSPHATE (ug-at/l)
2.8
2.2
1.6
1.0
0.4
5
15
25
35
SECCHI DEPTH (m)

Figure 38.

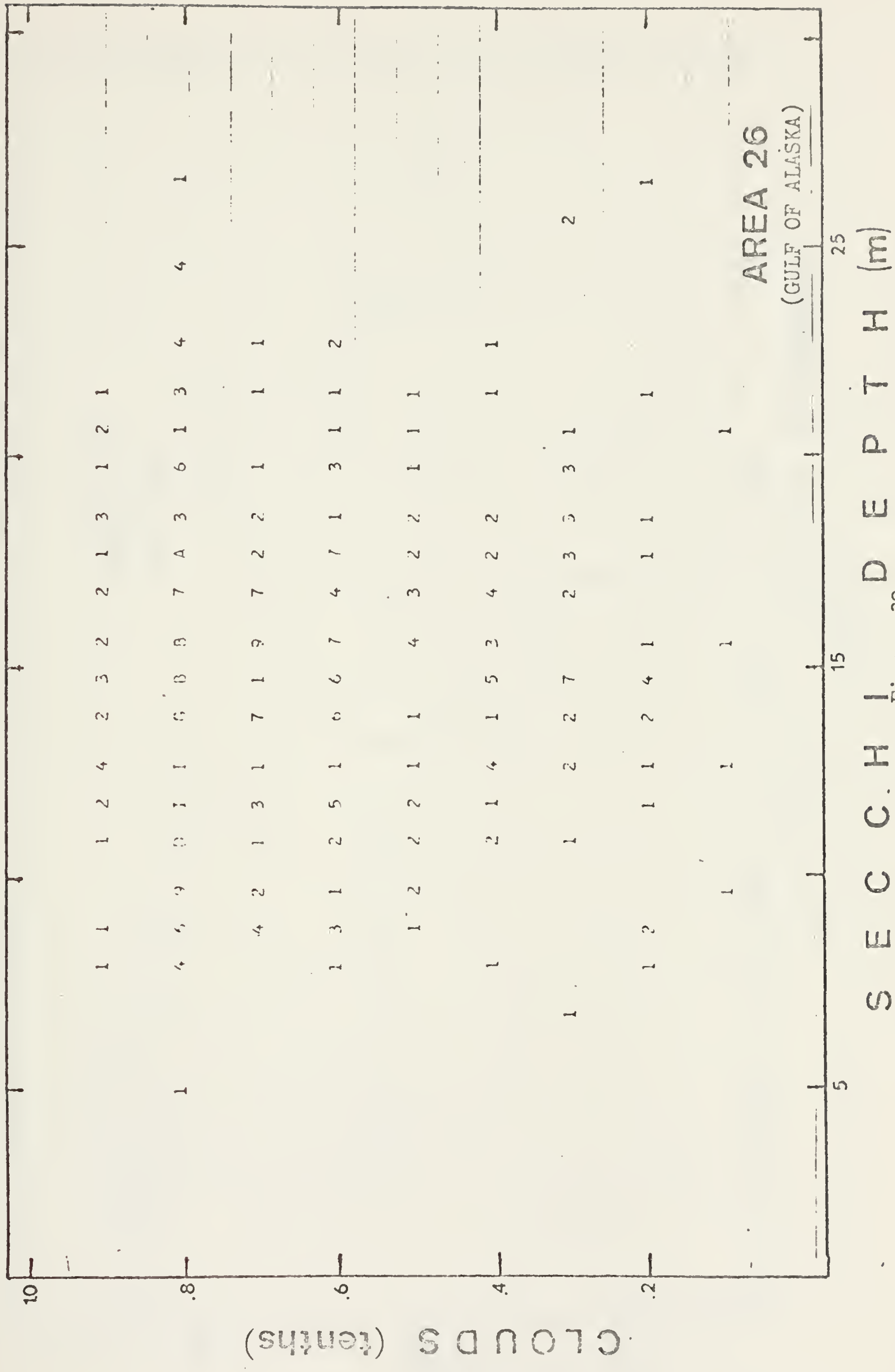

AREA 26
(GULF OF ALASKA)
SECCHI DEPTH (m)
5
15
25
CLOUDS (tenths)
10
.8
.6
.4
.2

Figure 39.

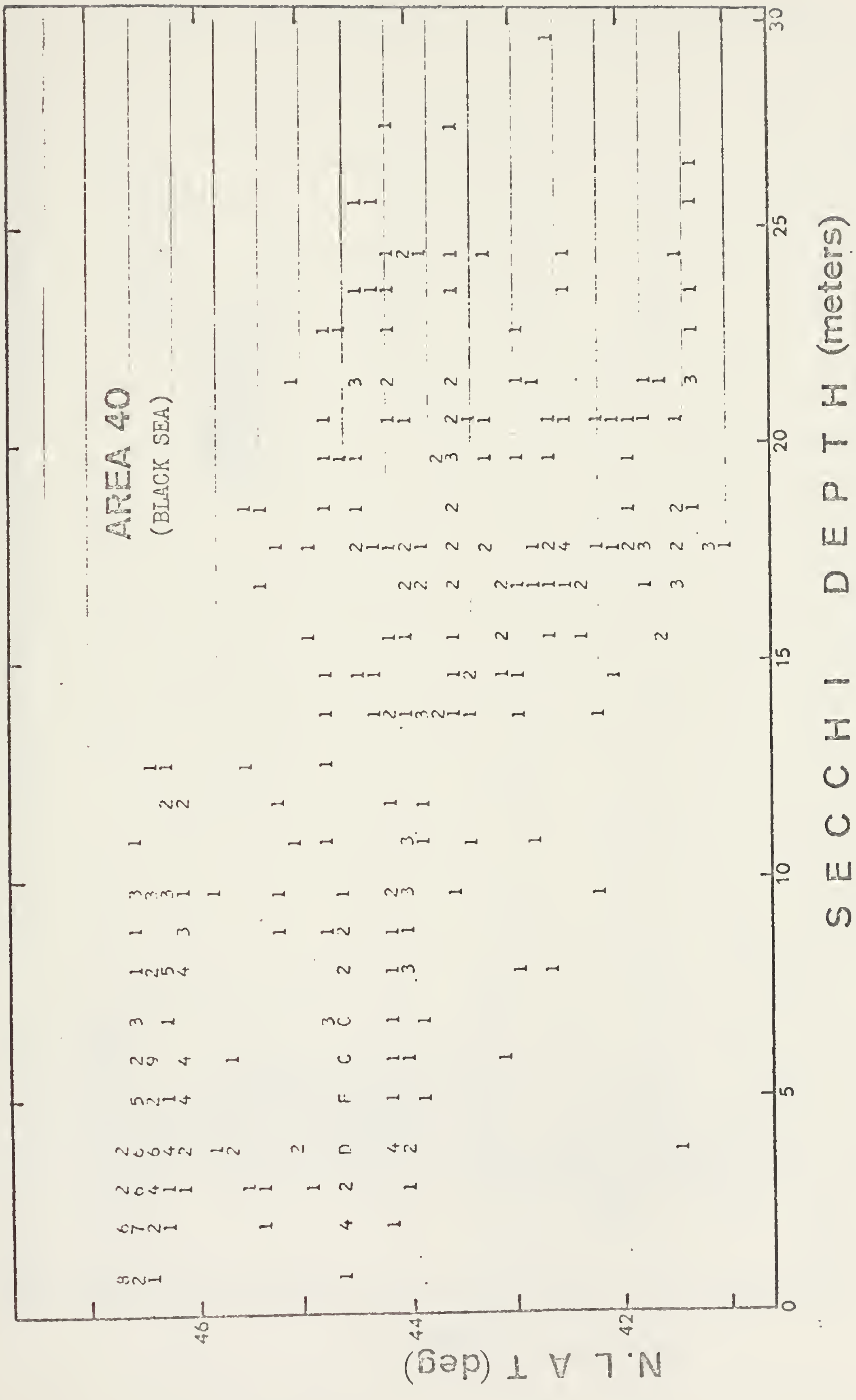

AREA 40
(BLACK SEA)
SECCHI DEPTH (meters)
N. LAT (deg)
0
5
10
15
20
25
30
46
44
42

Figure 40.

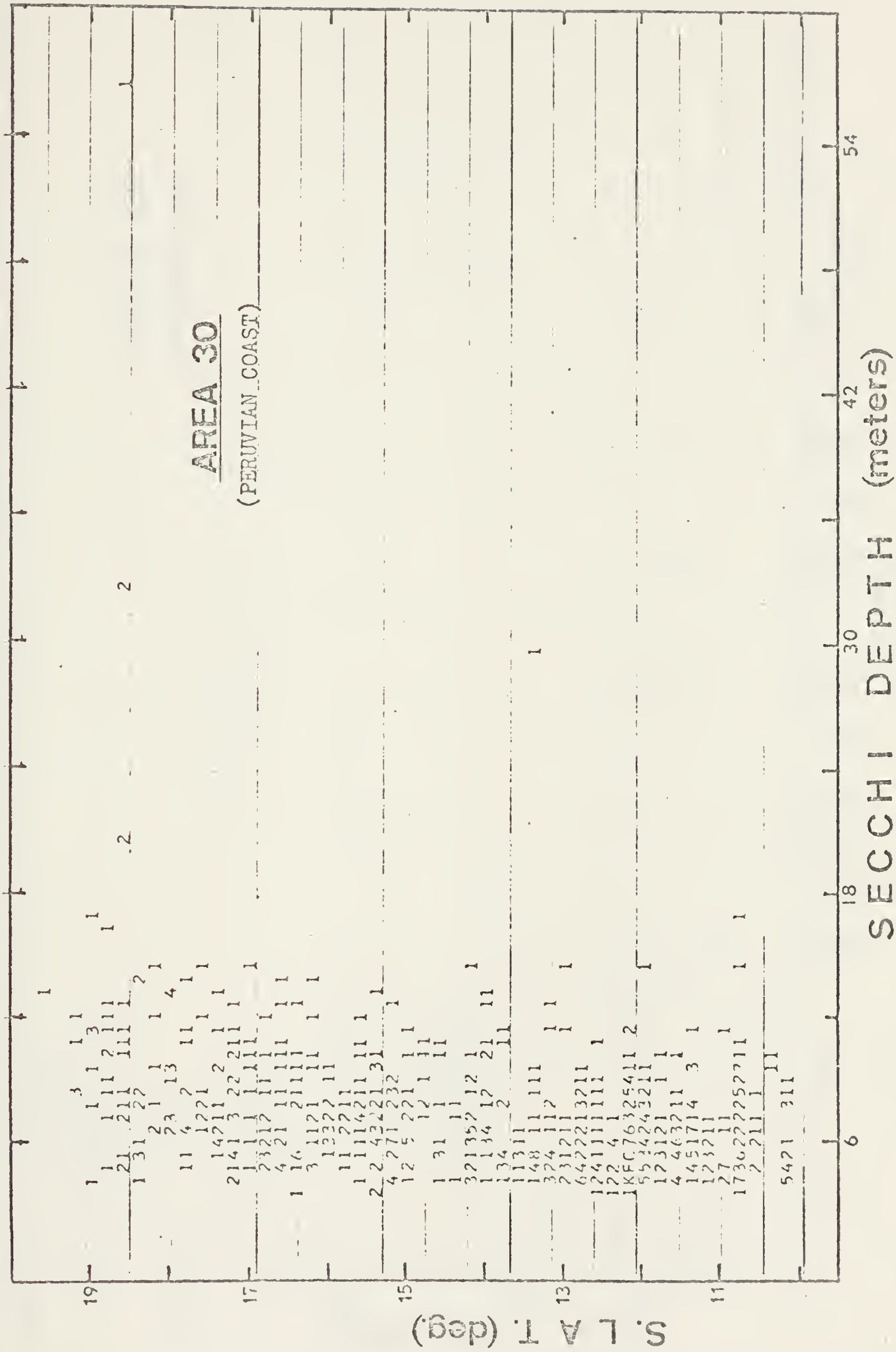

AREA 30
(PERUVIAN COAST)
SECCHI DEPTH (meters)
6
18
30
42
54
S. L A T. (deg)
19
17
15
13
11

Figure 41.

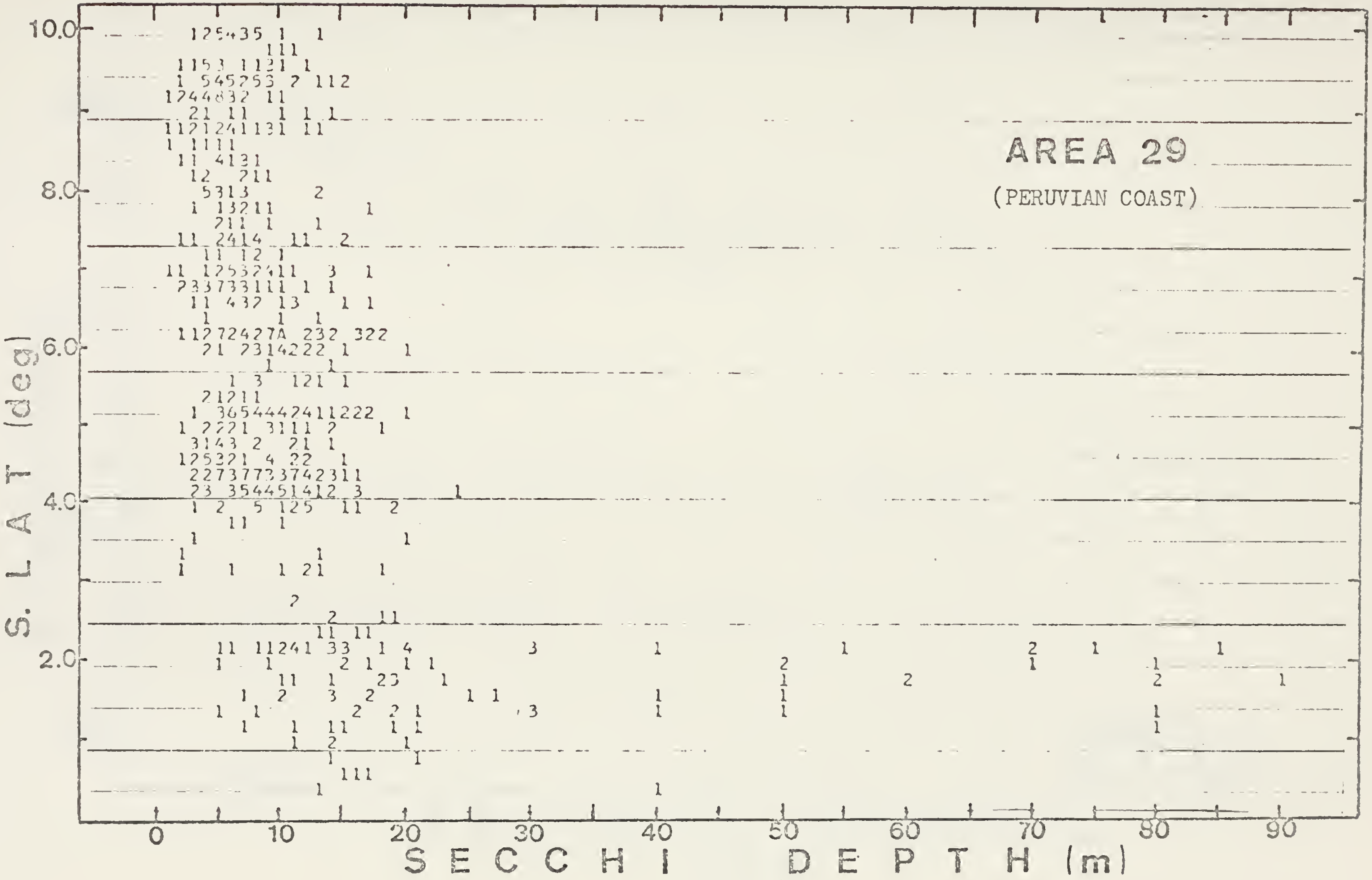

AREA 29
(PERUVIAN COAST)
S. LAT (deg)
10.0
8.0
6.0
4.0
2.0
0
10
20
30
40
50
60
70
80
90
SECCHI DEPTH (m)

Figure 42.

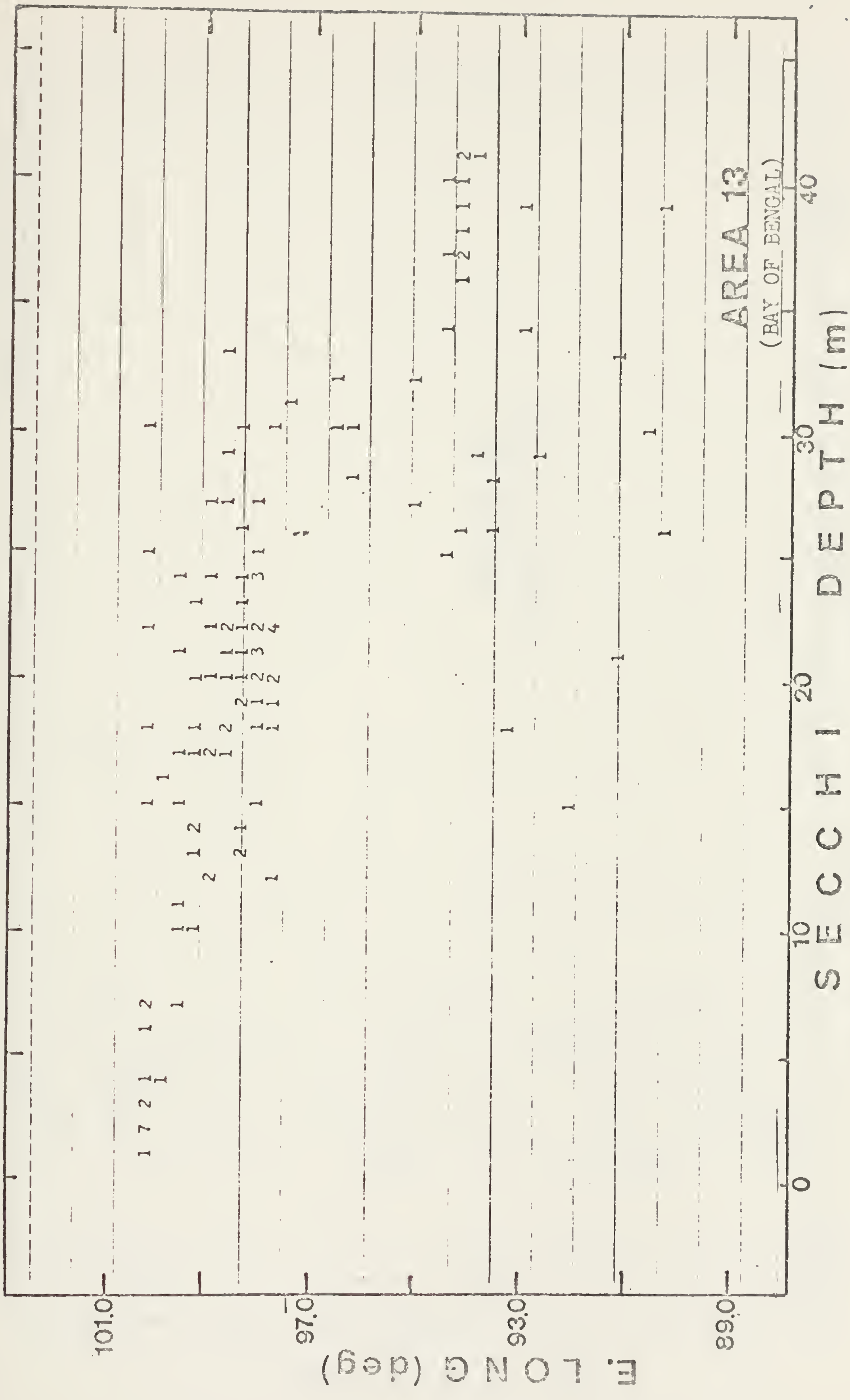

AREA 13
(BAY OF BENGAL)
SECCHI DEPTH (m)
0
10
20
30
40
E. LONG (deg)
101.0
97.0
93.0
89.0

Figure 43.

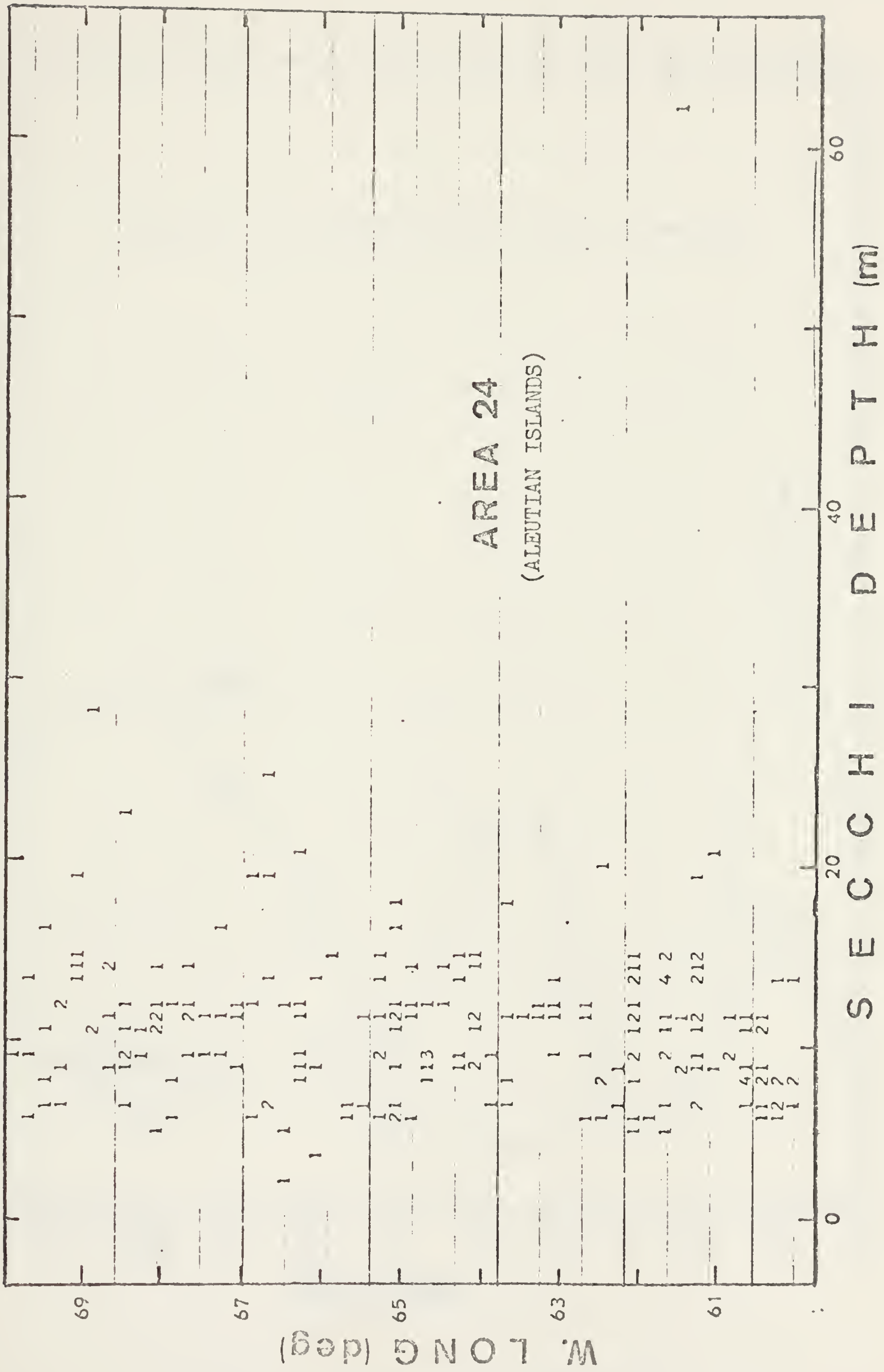

AREA 24
(ALEUTIAN ISLANDS)
S E C C H I D E P T H (m)
0
20
40
60
W. L O N G (deg)
69
67
65
63
61

Figure 44.

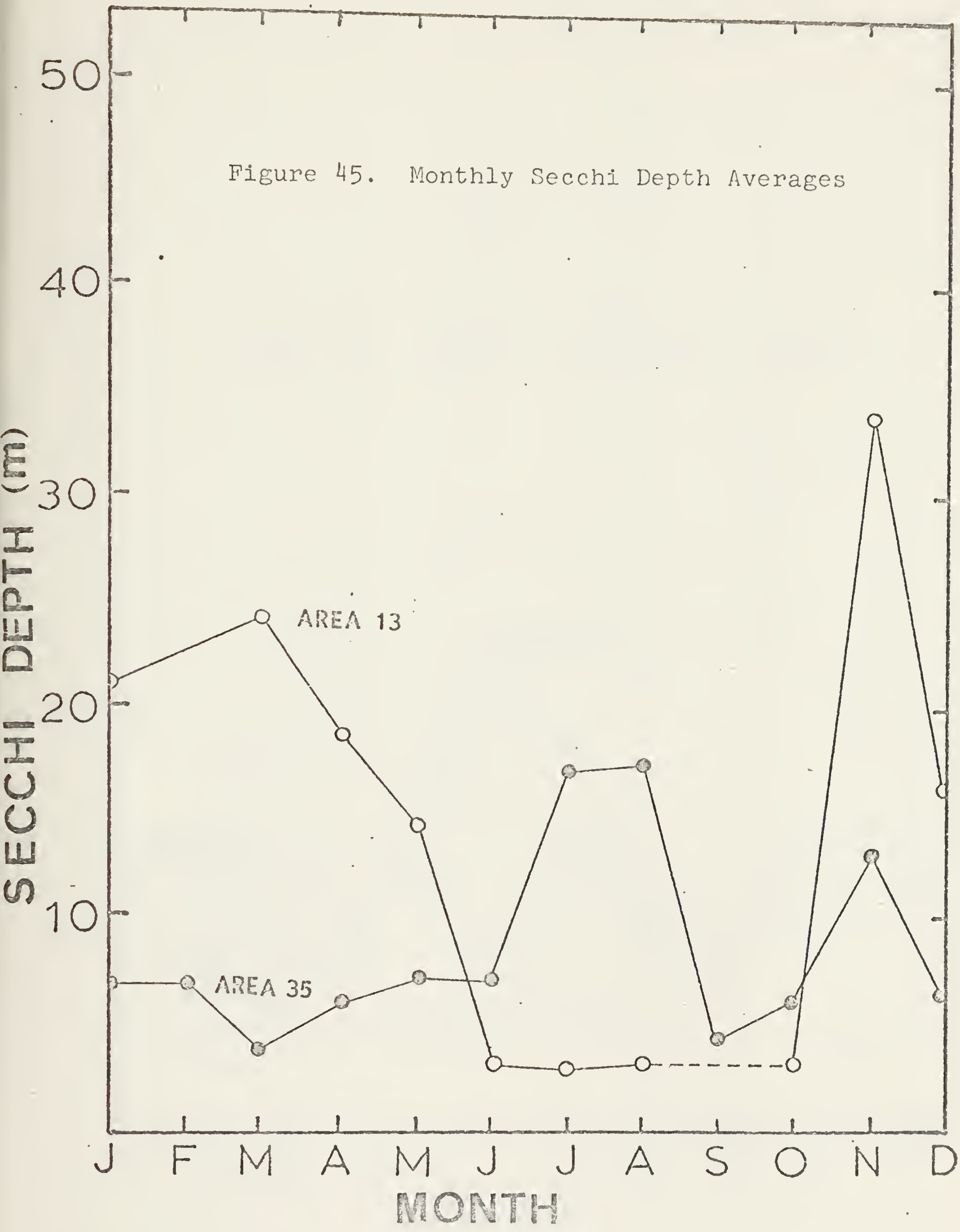


Figure 45. Monthly Secchi Depth Averages

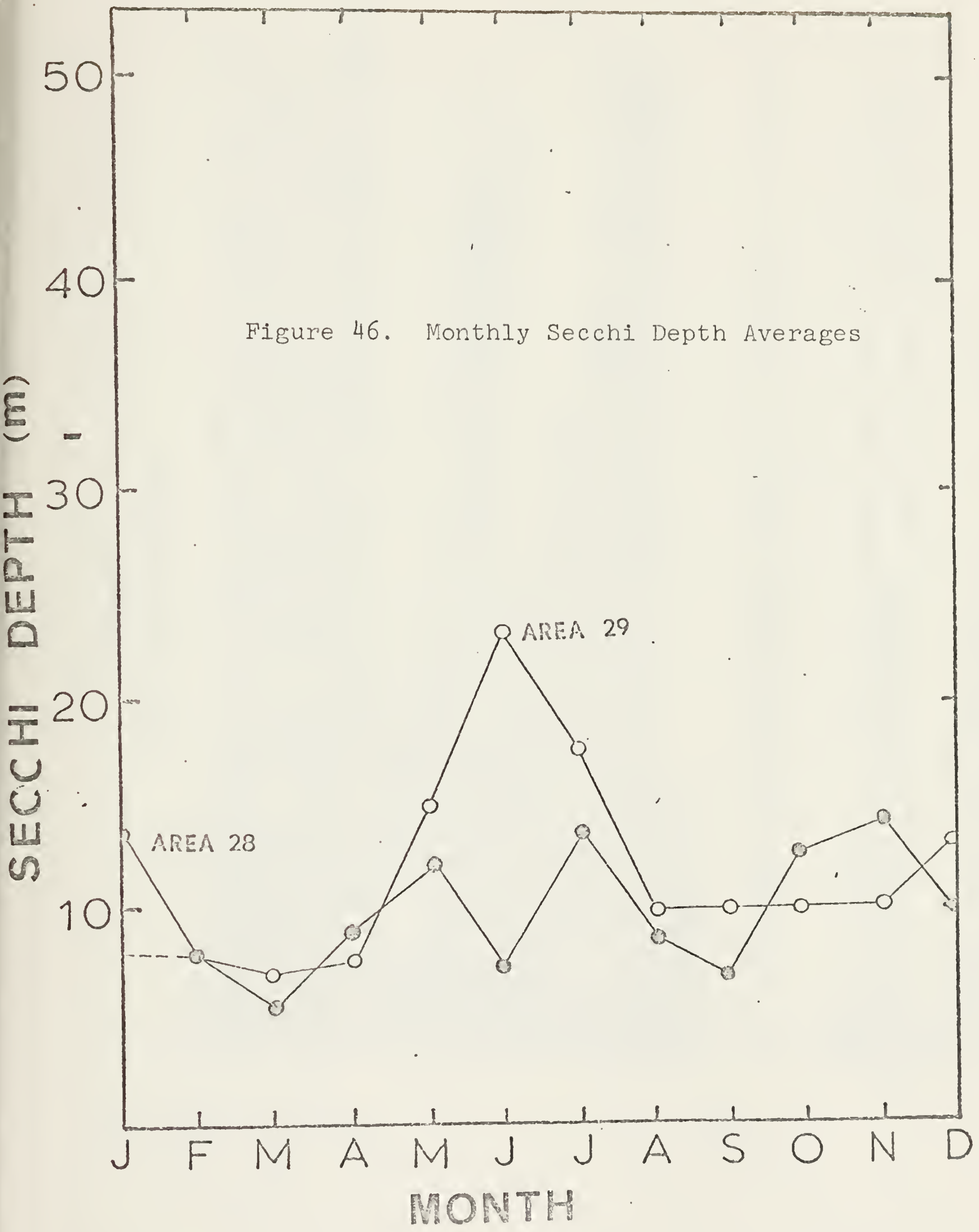


Figure 46. Monthly Secchi Depth Averages

```
C                                 APPENDIX A
C
C                            DATA SCREEN PROGRAM
C
C
C     PROGRAM READS SEQUENTIAL A-SHEET DATA FROM STATION AND DETAIL CARDS
C     AND DETERMINES IF THE LATITUDE AND LONGITUDE ARE CORRECT FOR THE
C     DESIRED AREA OF ANALYSIS.  SCREENING THEN TAKES PLACE TO ELIMINATE
C     DATA WHERE DEPTH LIMIT IS EXCEEDED OR WHERE EITHER SECCHI DEPTH OR
C     THE PARAMETER(S) CHOSEN EQUAL ZERO.  SEA SURFACE TEMPERATURE IS
C     SCREENED AS AN EXAMPLE.  A TOTAL COUNT OF DATA AND A COUNT OF DATA
C     LOST DUE TO ZERO SECCHI DEPTH VALUE ARE MADE.  A ZERO SECCHI DEPTH
C     READING INDICATES NO DATA OR STD DATA.  SECCHI DEPTH MONTHLY AVERAGES
C     ARE COMPUTED AND PARAMETER VALUES ARE THEN STORED IN MATRICIES ON
C     DISC FOR BIOMED ANALYSIS.
      REAL*4      N2N,N3N,MO
      INTEGER*4 XD,XM,XTM,YD,YM,YTM
      DIMENSION XD(0500),XM(0500),XTM(0500),YD(0500),YM(0500),YTM(0500)
     X,DEP(0500),COL(0500),TP(0500),CD(0500),KD1(0500),MO(0500)
      DIMENSION DEPTH(0500),TEMP(0500),SAL(0500),SIGMAT(0500),OXY(0500)
     X,PO4(0500),PTOT(0500),N2N(0500),N3N(0500),SIL(0500),KD3(0500)
      DIMENSION ALAT(0500),ALON(0500)
      DIMENSION SUMO(12),TOT(12),AVTP(12)
      DATA SUMO/12*0.0/,TOT/12*0.0/,AVTP/12*0.0/
      DATA  ALAT/0500*0.0/,ALON/0500*0.0/,MO/0500*0.0/
      DATA   XD,XM,XTM,YD,YM,YTM,DEP,COL,TP,CD,KD1,DEPTH,TEMP,SAL,SIGMA
     XT,OXY,PO4,PTOT,N2N,N3N,SIL,KD3/0500*0,0500*0,0500*0,0500*0,0500*0
     X,0500*0,0500*0.0,0500*0.0,0500*0.0,0500*0.0,0500*0,0500*0.0,0500*
     X0.0,0500*0.0,0500*0.0,0500*0.0,0500*0.0,0500*0.0,0500*0.0,0500*0.
     X0,0500*0.0,0500*0/
      CALL REREAD
C
C
C     THIS SECTION READS STATION MASTER CARD AND DETERMINES IF LATITUDE
C     AND LONGITUDE ARE WITHIN DESIRED LIMITS
C
C
      M=0
      N=1
    1 READ(5,10,END=21)    XD(N),XM(N),XTM(N),YD(N),YM(N),YTM(N),MO(N),D
     XEP(N),COL(N),TP(N),CD(N),KD1(N)
   10 FORMAT(1X,2I2,I1,1X,I3,I2,I1,3X,F2.0,F4.0,2X,2F2.0,11X,F1.0,29X,I
     X1)
      IF(KD1(N).GT.1)GO TO 1
   11 CONTINUE
      IF((XM(N).EQ.0).AND.(XTM(N).EQ.0))  XTM(N)=XTM(N)+1
      IF((YM(N).EQ.0).AND.(YTM(N).EQ.0))  YTM(N)=YTM(N)+1
      ALAT(N)=FLOAT(XD(N))+(FLOAT(XM(N))+(FLOAT(XTM(N))*.1))/60.0
```

APPENDIX A (Con't)

```
      ALON(N)=FLOAT(XD(N))+(FLOAT(YM(N))+(FLOAT(YTM(N))*.1))/60.0
C
C     THE FOLLOWING TEST THROWS OUT STATION DATA IF SECCHI DEPTH EQUALS ZERO
C
   12 CONTINUE
      IF(TP(N).EQ.0.0)M=M+1
      IF(TP(N).EQ.0.0)GO TO 1
C
C
    2 READ(5,11,END=21)   DEPTH(N),TEMP(N),SAL(N),SIGMAT(N),OXY(N),PO4(N
     X),PTOT(N),N2N(N),N3N(N),SIL(N),KD3(N)
   20 FORMAT(18X,F4.0,F5.2,F4.2,F5.0,5X,F4.0,5F3.0,9X,I1)
C
C     THE FOLLOWING SECTION SCREEN KEEPS ONLY SURFACE DATA AND ELIMINATES
C     ANY PARAMETER DATA EQUAL TO ZERO
C
      IF(KD3(N).EQ.1)GO TO 3
      IF(DEPTH(N).GT.1.0) GO TO 2
C
C     THE FOLLOWING SECTION COMPUTES MONTHLY SECCHI DEPTH AVERAGES
C
      IF(MO(N).EQ.0.0)   GO TO 67
      IMO=MO(N)
      DO 55 I=1,12
      IF(I.EQ.IMO)    GO TO 66
   55 CONTINUE
      GO TO 67
   66 CONTINUE
      SUMO(I)=SUMO(I)+TP(N)
      TOT(I)=TOT(I)+1.0
      AVTP(I)=SUMO(I)/TOT(I)
   67 CONTINUE
      N=N+1
      GO TO 1
C
C
    3 READ(99,10) XD(N),XM(N),XTM(N),YD(N),YM(N),YTM(N),DEP(N),COL(N),T
     XP(N),CD(N),KD1(N)
      GO TO 11
C
C
   21 CONTINUE
      L=N-1
      WRITE(6,100)(AVTP(I),I=1,12)
  100 FORMAT('0','MONTHLY AVE IS:',F4.0)
      WRITE(3,200)(ALAT(N),ALON(N),DEP(N),COL(N),
     XTP(N),CD(N),KD1(N),DEPTH(N),TEMP(N),SAL(N),SIGMAT(N),OXY(N),PO4(N
     X),PTOT(N),N2N(N),N3N(N),SIL(N),KD3(N),MO(N),N=1,L)
```

APPENDIX A (Con't)

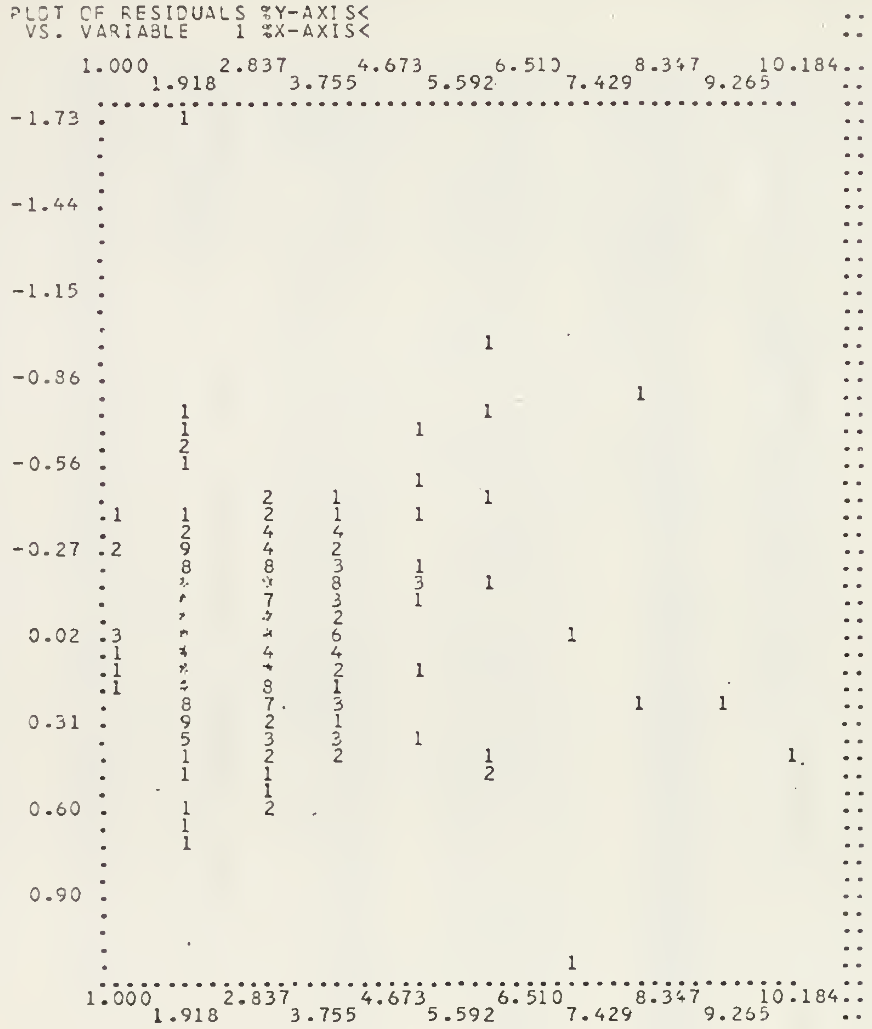
```
200 FORMAT(F5.2,F6.2,F5.0,2F3.0,F2.0,I1,F5.0,F6.2,F5.2,F6.0,F5.0,5F4.
   X0,I1,F3.0)
    WRITE(6,300) N
300 FORMAT('0','TOTAL DATA COUNT THIS MARSDEN SQUARE:',I7)
    WRITE(6,400)M
400 FORMAT('0','LOSS DUE TO SECCHI DEPTH EQUAL TO ZERO THIS MAR-SQ:',
   XI6)
    WRITE(6,500)(ALAT(N),ALON(N),DEP(N),COL(N),
   XTP(N),CD(N),KD1(N),DEPTH(N),TEMP(N),SAL(N),SIGMAT(N),OXY(N),PO4(N
   X),PTOT(N),N2N(N),N3N(N),SIL(N),KD3(N),MO(N),N=1,10)
500 FORMAT(' ',F5.2,F6.2,F5.0,2F3.0,F2.0,I1,F5.0,F6.2,F5.2,F6.0,F5.0,
   X5F4.0,I1,F3.0)
    STOP
    END
```

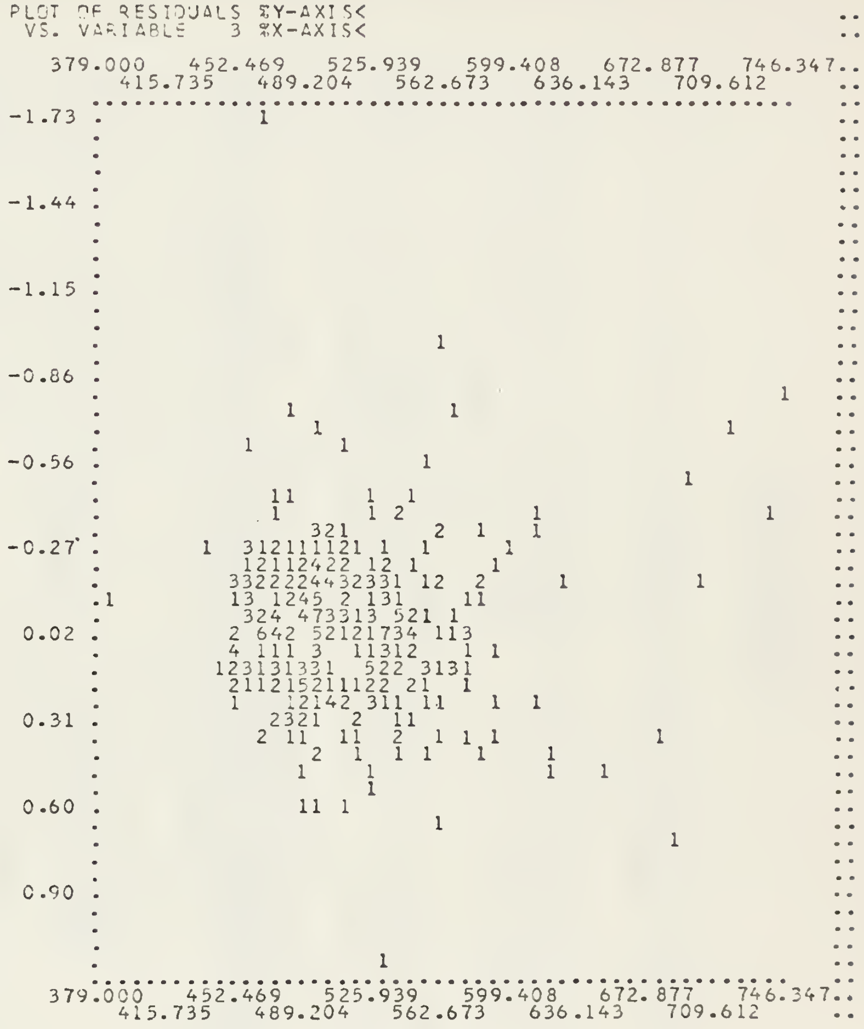
```
BMD02R - STEPWISE REGRESSION - REVISED JANUARY 29, 1970
HEALTH SCIENCES COMPUTING FACILITY, UCLA

PROBLEM CODE                    BROWN
NUMBER OF CASES                   360
NUMBER OF ORIGINAL VARIABLES        3
NUMBER OF VARIABLES ADDED           1
TOTAL NUMBER OF VARIABLES           4
NUMBER OF SUB-PROBLEMS              1
THE VARIABLE FORMAT IS   (16X,2F3.0,25X,F5.0)



  VARIABLE           MEAN       STANDARD DEVIATION
  COLOR   1        2.77778             1.19681
   TRAN   2       22.88055             7.61785
 OXYGEN   3      506.84424            47.65605
 LNTRAN   4        3.06051             0.41078



CORRELATION MATRIX

VARIABLE        1          2          3          4
 NUMBER

   1          1.000     -0.628      0.572     -0.701
   2                     1.000     -0.560      0.942
   3                                1.000     -0.634
   4                                           1.000



COVARIANCE MATRIX

VARIABLE        1          2          3          4
 NUMBER

   1          1.432     -5.726     32.608     -0.345
   2                    58.032   -203.183      2.948
   3                              2271.099   -12.411
   4                                           0.169
```

APPENDIX B SAMPLE BIOMED 02R OUTPUT

```
SUB-PROBLM     1
 DEPENDENT VARIABLE              4
 MAXIMUM NUMBER OF STEPS         8
 F-LEVEL FOR INCLUSION    0.010000
 F-LEVEL FOR DELETION     0.005000
 TOLERANCE LEVEL          0.001000


  STEP NUMBER     1
  VARIABLE ENTERED     1

  MULTIPLE R                 0.7007
  STD. ERROR OF EST.         0.2935

  ANALYSIS OF VARIANCE
                          DF     SUM OF SQUARES     MEAN SQUARE     F RATIO
        REGRESSION         1             29.746          29.746    345.404
        RESIDUAL         358             30.831           0.086

                VARIABLES IN EQUATION                     .                    VARIABLES NOT IN EQUATION
                                                          .
   VARIABLE        COEFFICIENT  STD. ERROR  F TO REMOVE   .      VARIABLE    PARTIAL CORR.     TOLERANCE     F TO ENTER
                                                          .
   %CONSTANT           3.72861 <                          .
   COLOR  1           -0.24052     0.01294   345.4036 %2< .       TRAN  2         0.90442        0.6056     1604.2783 %1<
                                                          .     OXYGEN  3        -0.39872        0.6731       67.4848 %2<


  STEP NUMBER     2
  VARIABLE ENTERED     3

  MULTIPLE R                 0.7563
  STD. ERROR OF EST.         0.2695

  ANALYSIS OF VARIANCE
                          DF     SUM OF SQUARES     MEAN SQUARE     F RATIO
        REGRESSION         2             34.648          17.324    238.517
        RESIDUAL         357             25.930           0.073

                VARIABLES IN EQUATION                     .                    VARIABLES NOT IN EQUATION
                                                          .
   VARIABLE        COEFFICIENT  STD. ERROR  F TO REMOVE   .      VARIABLE    PARTIAL CORR.     TOLERANCE     F TO ENTER
                                                          .
   %CONSTANT           5.05432 <                          .
    COLOR  1          -0.17248     0.01449   141.7768 %2< .       TRAN  2         0.89491        0.5458     1431.8018 %1<
   OXYGEN  3          -0.00299     0.00036    67.4849 %2< .

F-LEVEL OR TOLERANCE INSUFFICIENT FOR FURTHER COMPUTATION


 SUMMARY TABLE
   STEP               VARIABLE                   MULTIPLE                    INCREASE       F VALUE TO     NUMBER OF INDEPENDENT
  NUMBER          ENTERED  REMOVED             R            RSQ              IN RSQ      ENTER OR REMOVE   VARIABLES INCLUDED

    1              COLOR  1                 0.7007       0.4910             0.4910         345.4036              1
    2             OXYGEN  3                 0.7563       0.5720             0.0809          67.4849              2
```

SAMPLE BIOMED 02R OUTPUT(cont'd)





SAMPLE BIOMED 02R OUTPUT (cont'd)

BIBLIOGRAPHY

1. Arsen'yev, V.S., and Voytov, V.I., "Relative Transparency and Color of Bering Sea Water", Oceanology 8(1), 1968.

2. Atkins, W.R.G., Jenkins, P.G., and Warren, F.J., "The Suspended Matter in Sea Water and its Seasonal Changes as Affecting the Visual Range of the Secchi Disc," J. Mar. Biol. Ass. U. K., Vol. 33, pp. 497-508, 1954.

3. Boden, B.P., Kampa, E.M., and Snodgrass, J.M., "Underwater Daylight Measurements in the Bay of Biscay," J. Mar. Biol. Ass. U. K., Vol. 39, pp. 227-238, 1960.

4. Bumpus, D.F. and Clarke, A.H., Hydrography of the Western Atlantic: Transparency of the Coastal and Oceanic Waters of the Western Atlantic, Woods Hole Oceanographic Institution Technical Report 10, 1947.

5. Cialdi, A. and Secchi, P.A., "On the Transparency of the Sea," Translation by Professor Albert Collier, Limnology and Oceanography, 13, 391-394, 1968.

6. Daniel, C. and Wood, F.S., Fitting Equations to Data, pp. 20-24, Wiley, 1971.

7. Dixon, W.J., Biomedical Computer Programs, University of California Press, Berkeley, 1971.

8. Frederick, M.A., An Atlas of Secchi Disc Transparency Measurements and Forelule Color Codes for the Oceans of the World, M.S. Thesis, U.S. Naval Postgraduate School, Monterey, 1970.

9. Gall, M.H.W., "Measurements to Determine Extinction Coefficients and Temperature Gradients in the North Sea and English Channel," J. Mar Biol. Assoc. U. K., Vol. 28, pp. 757-780, 1949.

10. Graham, J.J., "Secchi Disc Observations and Extinction Coefficients in the Central and Eastern North Pacific Ocean," Limnology and Oceanography, 11(2), 184-190, 1966.

11. Holmes, R.W., "The Secchi Disc," Martek Mariner, 2(1), 1-4, 1970.

12. Holmes, R.W., "The Secchi Disc in Turbid Coastal Waters," Limnology and Oceanography, 15(5), 688-694, 1970.

13. Jerlov, N. G., Optical Oceanography, Elsevier, Amsterdam, London, New York, 194 p., 1968.

14. Kampa, E.M., "Underwater Daylight Measurements in the Sea of Cortex," Deep-Sea Research, 17, 271-280, 1970.

15. Kampa, E.M., and Bowden, B.P., "Light Generation in a Sonic-Scattering Layer," Deep-Sea Research, 4, 73-92, 1957.

16. Murphy, G.I., "Effect of Water Clarity on Albacore Catches," Limnology and Oceanography, 4(1), 86-93, 1959.

17. Nie, N.H., Bent, D.H., and Hull, H.C., Statistical Package for Social Sciences, McGraw-Hill, Inc., San Francisco, 1970.

18. Poole, H.H., and Atkins, W.R.G., "Photoelectric Measurement of Submarine Illumination throughout the Year," Journal of the Marine Biological Association of the United Kingdom, 16, 297-324, 1929.

19. Russell, H.D., and Clarke, G.L., The Transparency of East Indian Waters and Adjacent Areas, Woods Hole Oceanographic Institution Technical Report 2, 1944a.

20. Russell, H.D., and Clarke, G.L., The Transparency of Icelandic, North and Central American, West Indian, Hawaiian Territory, and Fiji Island Waters, Woods Hole Oceanographic Institution Technical Report 3, 1944b.

21. Ryther, J.H., "Photosynthesis and Fish Production in the Sea," Science, 166, 72-76, 1969.

22. Tyler, J.E., "The Secchi Disc," Limnology and Oceanography, 13(1), 1-6, 1968.

23. Uda, M., "Oceanography of the Subarctic Pacific Ocean," Journal of the Fisheries Research Board of Canada, 20(1), 119-179, 1963.

24. Visser, M.P., "Secchi Disc and Sea Colour Observations in the North Atlantic Ocean during the Navado III Cruise, 1964-1965, Aboard H. Neth. M.S. 'Snellius' (Royal Netherlands Navy)," Netherlands Journal of Sea Research, 3(4), 553-563, 1967.

25. Visser, M.P., "The Turbidity of the Southern North Sea," Deutschen Hydrographischen Zeitschrift, 3(3), 97-117, 1969.

26. Voitov, V.I., and Dement'yeva, M.G., "Relative Transparency of the Indian Ocean," Okeanologiya 10(1), 48-50, 1971.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Documentation Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0212 Naval Postgraduate School Monterey, California 93940	2
3.	Department of Oceanography Naval Postgraduate School Monterey, California 93940	3
4.	Officer in Charge Fleet Numerical Weather Facility Naval Postgraduate School Monterey, California 93940	1
5.	Commanding Officer and Director Naval Undersea Research & Development Center Attn: Code 2230 San Diego, California 92152	1
6.	Director, Naval Research Laboratory Attn: Tech. Services Info. Officer Washington, D.C. 20390	1
7.	Office of Naval Research, Code 4800 Department of the Navy Washington, D.C. 20360	1
8.	Oceanographer of the Navy The Madison Building 732 N. Washington Street Alexandria, Virginia 22314	1
9.	Naval Oceanographic Office Attn: Library Washington, D.C. 20390	1
10.	Dr. Robert S. Andrews Department of Oceanography Naval Postgraduate School Monterey, California 93940	1
11.	Mr. Roswell W. Austin Visibility Laboratory Scripps Institution of Oceanography La Jolla, California 92037	1

12. Dr. Hasong Pak 1
Department of Oceanography
Oregon State University
Corvallis, Oregon 97331

13. Dr. Wayne V. Burt 1
Department of Oceanography
Oregon State University
Corvallis, Oregon 97331

14. Lt. Patrick J. Brown 3
c/o M.E. Brown
125 Leidig Circle
Monterey, California 93940

15. Dr. Peyton Cunningham 6
Department of Physics
Naval Postgraduate School
Monterey, California 93940

16. Dr. Seibert Q. Duntley 1
Visibility Laboratory
Scripps Institution of Oceanography
La Jolla, California 92037

17. Mr. George Eck 1
Naval Air Development Center
Johnsville, Warminster, Pennsylvania 18974

18. Mr. Gus Griffin 1
Code 14
Naval Undersea Center
San Diego, California

19. Dr. R. C. Honey 1
Stanford Research Institute
Menlo Park, California

20. Mr. Kenneth V. Mackenzie 1
Ocean Sciences Department Code D503
Naval Undersea Research & Development Center
San Diego Division
San Diego, California 92152

21. Dr. Robert E. Morrison 1
Code 102 - OSC
Office of Naval Research
Arlington, Virginia 22217

22. Mr. Jerry Norton 1
Oceanography Department
Naval Postgraduate School
Monterey, California 93940

23. Mr. Larry Ott 3
Naval Air Development Center
Johnsville, Warminster, Pennsylvania 18974

24. Mr. Thomas J. Shopple 1
Naval Air Development Center
Johnsville, Warminster, Pennsylvania 18974

25. Dr. S. P. Tucker 10
Department of Oceanography
Naval Postgraduate School
Monterey, California 93940

26. Mr. John E. Tyler 1
Visibility Laboratory
Scripps Institution of Oceanography
La Jolla, California 92037

27. Mr. Lowell Van Billiard 1
Naval Ships Engineering Center
Prince Georges Center
Hyattsville, Maryland 20782

28. Mr. Alan Baldridge, Librarian 1
Hopkins Marine Station
Pacific Grove, California 93950

29. Mr. Ted Petzold 1
Visibility Laboratory
Scripps Institution of Oceanography
La Jolla, California 92037

30. Mr. W. J. Stachnik 1
Optical Systems
U.S. Navy Underwater Sound Laboratory
Fort Trumbull
New London, Connecticut 06320

31. Dr. Robert W. Holmes 1
Marine Science Institute
University of California
Santa Barbara, California 93106

32. Dr. Robert Andrews 1
Department of Oceanography, Code 58Ad
Naval Postgraduate School
Monterey, California 93940

33. LT Margaret Anne Frederick, USN 1
Fleet Numerical Weather Central
Monterey, California 93940

34. Dr. R. R. Dickson 1
Ministry of Agriculture, Fisheries & Food
Fisheries Laboratory
Lowestoft
Suffolk, England

35. Dr. M. P. Visser 1
Royal Netherlands Meteorological Institute
De Bilt, Netherlands

36. Mr. Henry Odum 2
Oceanographers Services Branch
National Oceanographic Data Center
Washington, D.C. 20390

37. Dr. Ronald Zaneweld 1
Department of Oceanography
Oregon State University
Corvallis, Oregon 97331

38. Mr. David Norman 1
W.R. Church Computer Center
Naval Postgraduate School
Monterey, California 93940

39. Dr. Robert E. Stevenson
ONR Scientific Liaison Office 1
Scripps Institution of Oceanography
La Jolla, CA 92037

40. Dr. Kendall Carder
Marine Science Institute 1
University of South Florida
St. Petersburg, Florida 33701

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

ORIGINATING ACTIVITY (Corporate author)
Naval Postgraduate School
Monterey, California 93940

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

REPORT TITLE
Correlation Coefficients Calculated on a World Wide Basis Between Observed Secchi Depths and Other Simultaneously Measured Standard Oceanographic Parameters

DESCRIPTIVE NOTES (Type of report and, inclusive dates)
Master's Thesis; March 1973

AUTHOR(S) (First name, middle initial, last name)
Patrick Joseph Brown

REPORT DATE
March 1973

7a. TOTAL NO. OF PAGES
123

7b. NO. OF REFS
26

. CONTRACT OR GRANT NO.

9a. ORIGINATOR'S REPORT NUMBER(S)

b. PROJECT NO.

c.

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

d.

0. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited

1 SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Naval Postgraduate School
Monterey, California 93940

3. ABSTRACT

The distributions of Secchi depths (i.e. water transparency) with simultaneously measured standard oceanographic parameters on file at the National Oceanographic Data Center are surveyed on a global basis. An inventory of many of the oceanographic parameters is given for all Marsden squares. Correlation coefficients between Secchi depths and eleven other parameters are also tabulated. Linear regression equations for some twenty-one selected ocean areas relating Secchi depth and the other parameters are presented, and in some cases plotted. No simple and consistent relations between Secchi depth and other parameters are evident; however, several trends are noted. Forel color and oxygen measurements show trends toward an inverse proportionality with Secchi depths while bottom depth data indicate a possible direct proportionality.

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Secchi Depths						
Oceanographic Parameters						
Transparency						
Sea Water Transparency						
Linear Regression Analysis						
Secchi Depth Data Distribution						
Ocean Transparency						
Transparency of the World's Oceans						
Optical Properties of Sea Water						

DD FORM 1 NOV 65 1473 (BACK)
S/N 0101-807-6821

Security Classification

A-31409

DUDLEY KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CA 93943

DUDLEY KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA 93943

Thesis
B8215 Brown 145991
c.1
Correlation coefficients calculated on a world wide basis between observed Secchi depths and other simultaneously measured standard oceanographic parameters.

14 FEB 79 25447
5 OCT 79 25459
22 Apr'86 INTERLIBRARY LOAN

Thesis 145991
B8215 Brown
c.1
Correlation coefficients calculated on a world wide basis between observed Secchi depths and other simultaneously measured standard oceanographi parameters.

thesB8215
Correlation coefficients calculated on a
3 2768 002 08025 1
DUDLEY KNOX LIBRARY